Radiological Health Data

VOLUME V, NUMBER 7

JULY 1964

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis and interpretation of data on environmental radiation levels. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

Radiological Health Data is published by the Public Health Service on a monthly basis. Data are provided to the Division of Radiological Health by other Federal agencies, State health departments, and foreign governments. Pertinent original data and interpretive papers are invited from investigators. Accepted material will be appropriately credited. The reports are reviewed by a Board of Editorial Advisors with representatives from the following Federal agencies:

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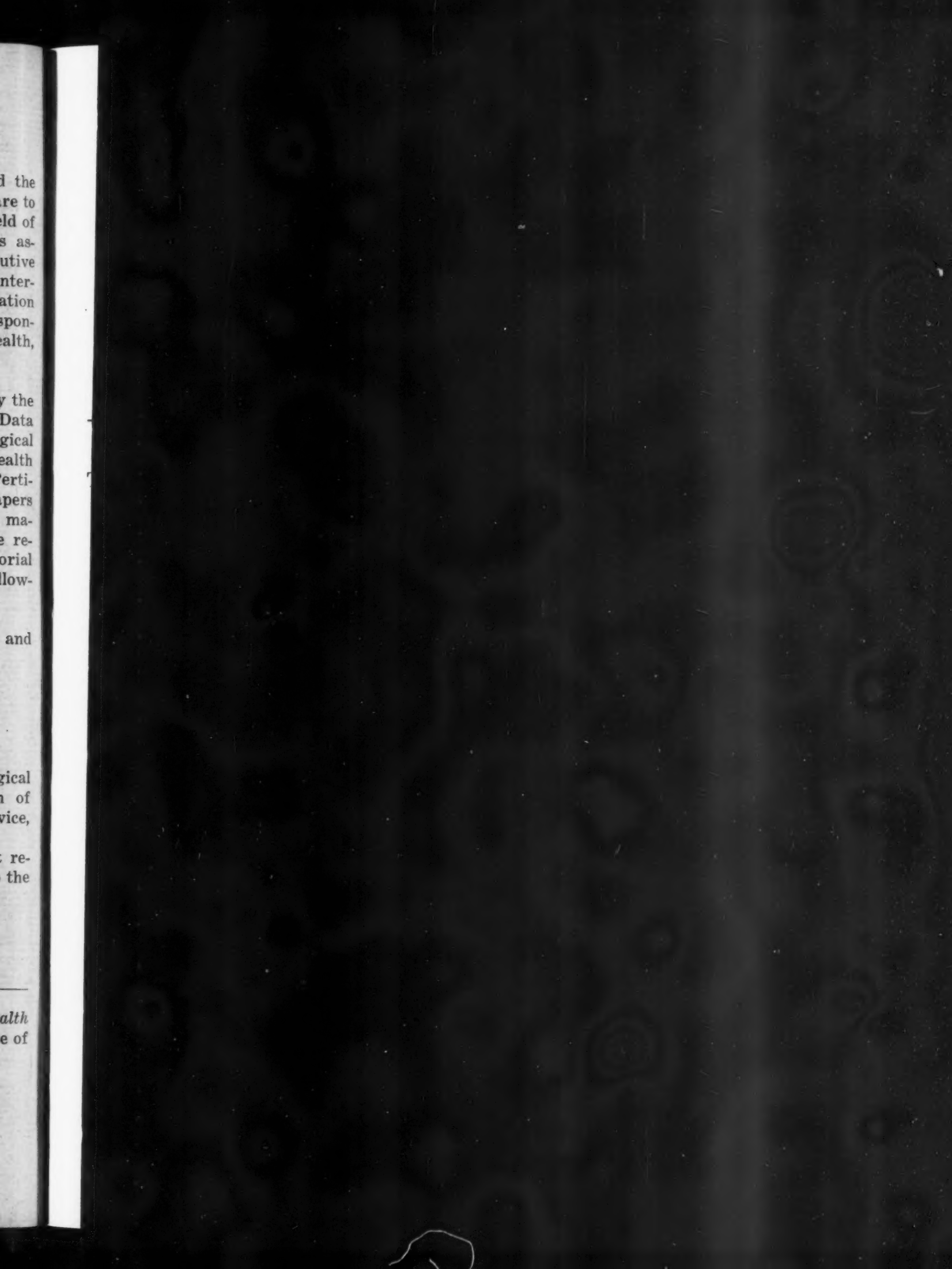

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

Section I—Air and Fallout

FISSION PRODUCT BETA ACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of gross beta activity in air and precipitation provides one of the earliest and most sensitive indications of changes in environmental fission product activity. Although this surveillance does not provide enough information to assess human radiation exposure from fallout, it is widely used as the basis of alerting systems for determining when to intensify monitoring in other phases of the environment.

Surveillance data from a number of national programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. Data provided by programs of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization are presented individually in tabular form and are also shown by beta concentration isograms in figure 6.

1. Radiation Surveillance Network, March 1964

Division of Radiological Health,
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) of the PHS Division of Radiological Health, which gathers samples from 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The alerting function of the Network is provided by field estimates of the gross beta activity of airborne particulates on the filters. These determinations are performed about 5 hours after the end of the sampling period to eliminate interference from naturally-occurring radon daughters. The Network station operators regularly report their field estimates to the Radiation Surveillance Center, Division of Radiological Health, Washington, D. C. When unusually high air levels are reported, appropriate Federal and State officials are notified. These field estimates are reported elsewhere on a monthly basis (*1*).

Air

Airborne particulates are collected continuously on a carbon-loaded cellulose dust filter 4 inches in diameter. A volume of about 1800 cubic meters of air is drawn through the filter during the 24-hour sampling period by a high volume centrifugal blower.

The filters are forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, and the gross beta activity is measured, using a thin-window, gas-flow proportional counter, calibrated with a 38,700-pc Sr^{90}–Y^{90} Standard.[1] Each filter is counted at least 3 days after the end of the sampling period and again 7 days later. The initial 3-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. By using the two counts and the Way-Wigner formula (*2*), the age of fission

[1] The Sr^{90}–Y^{90} source currently used as a standard was used from April 1962 to August 1963 as 40,000 pc total activity. Beginning with September 1963 data, the nominal activity of the standard was adjusted for decay (about 2½ percent per year) to 38,700 pc.

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS, MARCH 1964

products is estimated[2] and the activity extrapolated to the time of collection.[3] The daily concentrations and estimated age are reported by the PHS in a monthly RSN report (*1*).

The Network's highest activity during March was observed on the Las Vegas, Nevada, March 14 sample, (473 pc/m^3, with an estimated age of one day). The twenty samples with the highest activities during March are listed in table 1, which gives the gross beta concentration and estimated age for each.

The March 1964 average gross beta concentration in air for each station is given in table 2. The Network average for March (1.60 pc/m^3) was approximately 50 percent higher than the February average (1.09 pc/m^3). About half of this increase may be attributed to the five samples shown in table 1 with ages less than 100 days, which are evidently associated with the reported venting at the Nevada Test Site, March 13, 1964. The remaining part of the increase appears to be associated with the expected rise of old fission products during the spring months.

Time profiles of gross beta activity in air for eight RSN stations are shown in figure 2.

TABLE 1.—GROSS BETA ACTIVITY AND AGE OF THE TWENTY INDIVIDUAL RSN AIR FILTERS HAVING HIGHEST ACTIVITIES DURING MARCH 1964

Station	Date March	Concentration (pc/m^3)	Age (days)
Calif: Los Angeles	17	4.08	24
	18	3.80	>100
Fla: Jacksonville	11	4.30	>100
	31	4.01	>100
Miami	2	5.21	>100
Nev: Las Vegas	14	473	1
	15	4.43	40
	16	16.0	5
	18	4.62	>100
	19	4.44	79
	21	4.16	>100
	27	3.81	>100
Ore: Portland	31	3.86	>100
P. R: San Juan	6	4.10	>100
R. I: Providence	17	4.06	>100
Tex: Austin	1	5.07	>100
	13	4.24	>100
	20	4.25	>100
El Paso	22	4.27	>100
	26	4.69	>100

[2] If a sample contains a mixture of fresh and old fission products, the age estimated by the Way-Wigner formula is some intermediate value and cannot be used for estimating date of formation.

[3] The Way-Wigner formula is: $AT^{1.2}=C$, where A is the activity, T is the time (in any time unit) after fission product formation, and C is a constant equal to the activity at T=1.

TABLE 2.—GROSS BETA ACTIVITY IN SURFACE AIR AND PRECIPITATION, MARCH 1964

Station location		Air					Precipitation	
		Number of samples	Concentration (pc/m³)			Last profile in *RHD*	Average concentration [b] (pc/liter)	Total deposition (mc/m²)
			Maximum	Minimum	Average [a]			
Ala:	Montgomery	21	3.63	0.47	1.68			
Alaska:	Adak	28	1.33	<0.10	0.40	Nov 1963	380	31,800
	Anchorage	26	1.90	0.37	1.22	Jul 1964		
	Attu	26	1.21	<0.10	0.54	Dec 1963	480	5,000
	Fairbanks	21	1.61	0.52	1.03	Aug 1963		
	Juneau	27	3.34	<0.10	1.01	Sep 1963	380	2,100
	Kodiak	9	1.64	<0.10	0.69	Oct 1963	280	30,900
	Nome	17	1.44	0.18	0.65	Feb 1964		
	Point Barrow Island	31	1.16	0.11	0.67	Jan 1964		
	St. Paul Island	12	1.10	0.17	0.51	Mar 1964		
Ariz:	Phoenix	30	3.33	0.57	2.00	Sep 1963		
Ark:	Little Rock	29	3.37	0.38	1.70	Sep 1963	220	48,500
Calif:	Berkeley	22	3.24	0.17	1.01	Oct 1963	240	11,300
	Los Angeles	22	4.08	0.57	1.89	Feb 1964	260	4,100
Canal Zone:	Ancon	16	1.62	<0.10	0.73	Apr 1964		
Colo:	Denver	29	3.38	0.85	1.75	Nov 1963	300	1,700
Conn:	Hartford	31	2.69	0.37	1.27	Oct 1963	490	34,000
Del:	Dover	19	2.71	0.77	1.61	Aug 1963		
D. C:	Washington	31	3.21	0.29	1.65	Apr 1964	520	27,400
Fla:	Jacksonville	26	4.30	0.69	2.03	Oct 1963	420	15,900
	Miami	30	5.21	0.65	2.10	Feb 1964	420	8,500
Ga:	Atlanta	1	1.00	1.00	1.00	Jul 1964	260	28,100
Guam:	Agana	31	2.85	0.38	1.20	Apr 1964		
Hawaii:	Honolulu	31	2.59	0.13	0.87	Feb 1964	270	29,900
Idaho:	Boise	30	2.27	0.42	1.00	Dec 1963	—	—
Ill:	Springfield	31	1.90	0.21	1.13	Mar 1964	440	1,100
Ind:	Indianapolis	31	2.93	0.37	1.43	Jul 1964	560	120,300
Iowa:	Iowa City	28	2.46	0.39	1.29	Jan 1964	570	31,400
Kans:	Topeka	28	2.65	0.31	1.48	Jul 1964	1,000	46,300
Ky:	Frankfort	24	2.42	0.40	1.58	Feb 1964	740	46,200
La:	New Orleans	31	3.33	0.28	1.46	Mar 1964	270	42,400
Maine:	Augusta	31	2.76	0.42	1.63	Mar 1964	810	81,400
	Presque Isle	27	2.04	0.27	1.08	Nov 1963	—	—
Md:	Baltimore	20	2.37	<0.10	1.38	Nov 1963	670	27,000
	Rockville	9	2.24	0.94	1.75	Mar 1964		
Mass:	Lawrence	30	2.57	0.38	1.45	Aug 1963	1,000	73,200
	Winchester	29	2.87	0.27	1.26	Apr 1964	1,100	88,000
Mich:	Lansing	31	2.57	0.55	1.78	Feb 1964	740	48,100
Minn:	Minneapolis	31	1.93	0.50	1.17	Mar 1964	640	21,800
Miss:	Jackson	29	3.74	0.17	1.92	Apr 1964	300	60,900
	Pascagoula	0				Dec 1963		
Mo:	Jefferson City	31	2.44	0.19	1.21	Jul 1964	470	39,200
Mont:	Helena	31	2.25	0.29	0.96	Nov 1963	740	9,600
Nebr:	Lincoln	13	7.14	<0.10	1.29	Apr 1964	—	—
Nev:	Las Vegas	27	473	0.85	18.7	Jul 1963	—	—
N. H:	Concord	22	3.33	0.28	1.90	Feb 1964		
N. J:	Trenton	31	2.62	0.39	1.33	Apr 1964	730	7,300
N. Mex:	Santa Fe	30	3.37	1.04	2.04	Dec 1963	740	16,500
N. Y:	Albany	22	2.05	0.44	1.09	Jul 1964	420	25,300
	Buffalo	29	1.98	0.30	1.29	Nov 1963	—	—
	New York	27	2.14	0.45	1.36	Dec 1963		
N. C:	Gastonia	30	3.45	0.28	1.76	Jan 1964	290	
N. Dak:	Bismarck	30	1.77	0.68	1.23	Feb 1964	650	34,200
Ohio:	Cincinnati	21	1.96	0.12	1.36	Aug 1963		5,000
	Columbus	30	2.33	<0.10	1.52	Apr 1964	390	85,100
	Painesville	31	3.03	0.64	1.94	Oct 1963	910	91,300
Okla:	Oklahoma	27	2.60	0.48	1.41	Apr 1964	440	11,000
	Ponca City	30	2.25	0.24	1.00	Oct 1963	350	8,300
Ore:	Portland	29	3.86	<0.10	1.43	Oct 1963	270	16,100
Pa:	Harrisburg	28	2.13	0.28	0.86	Jul 1964	360	9,700
P. R:	San Juan	25	4.10	0.48	1.37	Mar 1964	270	8,700
R. I:	Providence	28	4.06	0.36	1.59	Jan 1964	600	9,700
S. C:	Columbia	30	2.69	0.25	1.45	Dec 1963	400	68,500
S. Dak:	Pierre	28	1.83	0.47	1.09	Sep 1963	700	2,700
Tenn:	Nashville	30	3.16	0.66	1.79	Jan 1964	510	43,900
Tex:	Austin	30	5.07	0.74	2.39	Aug 1963	340	12,200
	El Paso	31	4.69	0.68	2.06	Jan 1964	720	16,000
Utah:	Salt Lake City	29	2.48	0.65	1.45	Aug 1963	450	27,700
Vt:	Barre	30	3.33	0.45	1.84	Sep 1963	400	42,300
Va:	Richmond	30	2.10	0.26	1.17	Sep 1963	310	15,100
Wash:	Seattle	31	1.52	<0.10	0.50	Jul 1964	330	20,500
W. Va:	Charleston	31	3.04	0.62	1.48	Dec 1963	1,400	119,000
Wisc:	Madison	30	2.56	0.65	1.64	Sep 1963	740	42,000
Wyo:	Cheyenne	29	3.03	0.68	1.45	Aug 1963	940	9,500
Network summary		1,947	473	<0.10	1.60			

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed before the average.
[b] The minimum concentration reported for a single sample is 200 pc/liter.
[c] Profile scheduled for August 1964.
[d] Dash indicates no evaporated sample received.

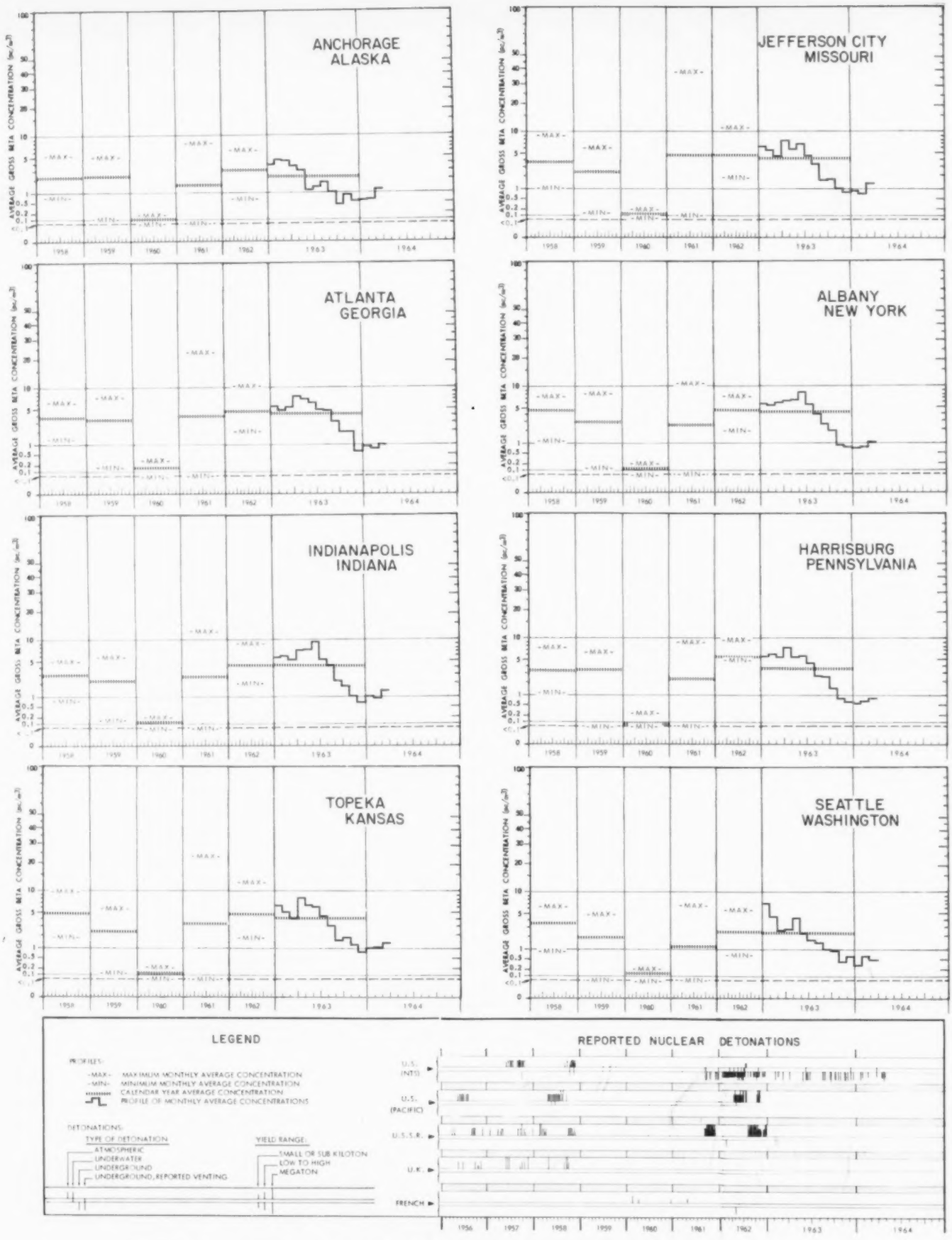

FIGURE 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR—RADIATION SURVEILLANCE NETWORK, 1958–MARCH 1964

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis, using funnels with collection areas of 0.4 square meter. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory for analysis. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made.

In the laboratory the gross beta activity in precipitation is determined by counting the evaporated sample by the same method used for analyzing the air filters, including the extrapolation of time of collection. Deposition for the sample is determined by:

$$D = \frac{CP}{1000}$$

where D is the deposition in nc/m^2, C is the concentration in pc/liter, and P is the depth of precipitation in mm. The individual values of deposition and depth of precipitation are totaled for the month, and the average concentration for the month, $\overline{C}$, is determined by:

$$\overline{C} = \frac{\Sigma D}{\Sigma P} \times 1000$$

The March 1964 average concentrations and total depositions are given in table 2.

2. National Air Sampling Network First Quarter 1964

Division of Air Pollution, Public Health Service

The necessity of having basic data on the nature and extent of air pollution throughout the United States led to the organization of the National Air Sampling Network (NASN) in 1953. The NASN analyzes air samples for the total quantity of suspended particulate matter, benzene-soluble organic matter, and gross beta radioactivity. Selected samples are also analyzed for nitrates, sulfates, and a number of metals. These analyses aid in the detection of trends in levels of pollution with respect to time, location, population density, climate, and other factors associated with air quality.

Gross Beta Activity in Air

NASN stations (see figure 3) are manned by cooperating Federal, State, and local agencies. The current basic network consists of 110 sampling stations which operate every year in 73 large cities and 37 nonurban areas. In addition, there are stations in 130 cities which operate every other year. Thus, there are 240 sampling stations in all in the NASN network, of which 175 are active in any given year.

Continuous 24-hour samples of suspended particulate matter are taken at each station. The samples, representing approximately 2,000 cubic meters of air, are collected on glass fiber filters on a biweekly random sampling schedule. They are then sent for analysis to the Network laboratory at the Robert A. Taft Sanitary Engineering Center in Cincinnati, Ohio. First quarter 1964 data appear in table 3.

Gross Beta Activity in Precipitation

The present reporting of gross beta activity in precipitation originated in 1959 when a precipitation collection and analysis program was established by the Weather Bureau Research Station in Cincinnati, Ohio, and the National Air Sampling Network. Monthly composite samples of precipitation are collected at 29 stations, which are located at Weather Bureau offices or airports. They are then forwarded to the Network laboratory for analysis.

The laboratory analyzes these samples for total solids and for a large number of metals and nonmetals. In addition, each sample is analyzed for fission product gross beta radioactivity if a sufficient volume of precipitation remains after chemical analyses have been made. Precipitation data for the first quarter 1964 are presented in table 4.

TABLE 3.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, NASN, FIRST QUARTER, 1964

[Concentrations in pc/m³]

Station location		Number of samples	Maximum	Minimum	Average
Ala:	Birmingham	7	2.4	0.8	1.8
	Gadsden	7	2.8	0.6	1.6
	Mobile	7	3.8	0.3	2.2
Alaska:	Anchorage	6	1.9	0.5	1.1
Ariz:	Grand Canyon Pk.[a]	6	3.7	1.4	2.4
	Maricopa Co.[a]	7	5.5	2.5	3.7
	Phoenix	7	4.7	2.0	3.0
	Tucson	6	2.7	0.6	1.9
Ark:	Little Rock	7	2.4	0.8	1.5
	Montgomery Co.[a]	4	2.9	0.9	2.0
	Texarkana	5	2.9	0.8	1.7
Calif:	Bakersfield	7	2.8	1.0	1.7
	Burbank	6	3.7	1.8	2.4
	Humboldt Co.[a]	5	3.0	0.2	1.1
	Los Angeles	6	3.8	0.7	2.1
	Monterey	7	3.6	1.1	1.8
	Oakland	6	2.6	0.7	1.6
	Pasadena	6	3.2	1.5	2.0
	Sacramento	7	3.5	0.8	1.6
	San Diego	6	3.5	1.8	2.4
	San Francisco	7	3.3	0.5	1.6
	Santa Ana	6	3.2	1.2	1.9
	Santa Barbara	7	4.0	0.6	2.1
Colo:	Denver	7	3.3	1.1	2.1
	Montezuma Co.[a]	7	4.9	1.6	2.8
Conn:	Hartford	6	2.5	0.6	1.5
	New Haven	6	2.2	0.9	1.5
Del:	Kent Co.[a]	5	2.5	0.5	1.2
	Wilmington	7	2.7	0.6	1.4
D. C:	Washington	5	2.6	1.2	1.9
Fla:	Florida Keys[a]	5	3.7	0.6	2.2
	Jacksonville	7	3.3	0.2	1.7
	Orlando	5	4.1	1.6	2.8
	Tampa	6	5.7	1.2	2.7
Ga:	Atlanta	7	3.3	0.6	1.8
Hawaii:	Honolulu	6	2.2	0.2	1.2
Idaho:	Boise	7	3.1	0.5	1.5
	Butte Co.[a]	7	2.2	0.6	1.5
Ill:	Chicago	5	2.4	1.0	1.7
	Cicero	6	2.9	0.9	1.6
	Moline	5	3.4	1.0	1.7
	Peoria	6	1.9	1.0	1.4
	Rock Island	6	3.8	0.9	2.0
Ind:	East Chicago	5	1.9	0.9	1.3
	Evansville	5	3.6	0.7	1.9
	Fort Wayne	6	2.5	0.6	1.7
	Gary	6	3.1	0.9	1.9
	Indianapolis	6	2.1	1.1	1.6
	Lafayette	5	2.5	0.8	1.6
	Parke Co.[a]	7	2.2	0.7	1.4
Iowa:	Davenport	3	1.9	1.4	1.7
	Delaware Co.[a]	5	1.6	0.4	1.1
	Des Moines	6	3.6	0.8	1.7
	Dubuque	7	2.8	1.1	1.6
Kans:	Kansas City	7	3.3	0.7	1.6
	Wichita	6	3.8	0.9	2.2
Ky:	Ashland	6	3.6	1.0	1.9
	Covington	5	2.7	1.1	1.9
	Louisville	5	2.3	1.1	1.7
	Newport	4	3.4	1.2	2.1
La:	Baton Rouge	7	4.0	0.7	1.8
	Lake Charles	7	2.9	0.8	1.4
	New Orleans	7	4.2	0.8	2.0
Maine:	Acadia Nat'l. Pk.[a]	6	3.9	0.9	2.2
	Portland	6	2.7	0.8	1.7
Md:	Baltimore	5	2.2	0.6	1.4
	Calvert Co.[a]	7	3.2	0.8	1.8
Mass:	Boston	6	4.4	1.4	2.2
	Springfield	7	2.8	0.7	1.8
Mich:	Detroit	7	1.9	0.5	1.3
	Wyandotte	5	1.8	1.1	1.4
Minn:	Duluth	6	2.0	0.9	1.4
	Minneapolis	7	1.9	0.4	1.2
	Moorhead	6	2.0	0.8	1.4
	St. Paul	7	2.6	0.5	1.6
Miss:	Jackson	7	3.2	0.4	1.7
Mo:	Kansas City	7	4.2	0.7	2.1
	Shannon Co.[a]	7	3.1	1.5	2.3
	St. Louis	7	2.7	0.8	1.5
Mont:	Glacier Nat'l. Pk.[a]	7	1.8	0.5	0.9
	Helena	7	1.7	0.8	1.2
Nebr:	Omaha	7	4.1	1.4	2.2
	Thomas Co.[a]	6	3.4	0.6	2.0
Nev:	Las Vegas	6	3.8	1.6	2.5
	White Pine Co.[a]	6	3.0	0.5	2.0
N. H:	Concord	5	2.9	0.6	1.7
	Coos Co.[a]	7	2.5	0.3	1.4
N. J:	Camden	7	3.0	0.7	1.7
	Clinton	5	2.3	0.8	1.7
	Marlton	3	2.6	1.7	2.2
	Newark	7	2.6	0.9	1.7
	New Brunswick	6	2.6	0.8	1.9
	Princeton	3	2.3	1.8	2.1
	Trenton	6	2.1	0.8	1.5
	Glassboro	5	2.4	1.5	1.9
N. M:	Albuquerque	7	4.0	1.5	2.6
	Rio Arriba Co.[a]	7	4.9	0.9	2.8
N. Y:	Cape Vincent[a]	7	2.6	0.5	1.5
	New York	7	2.3	0.8	1.4
N. C:	Cape Hatteras	7	3.0	1.4	2.3
	Charlotte	6	2.7	0.9	1.6
	Fayetteville	5	2.8	1.0	1.9
	Winston-Salem	7	3.0	0.6	1.8
N. Dak:	Bismarck	7	2.2	0.6	1.3
	Fargo	6	1.8	0.6	1.3
	Ward Co.[a]	5	4.1	0.6	1.8
Ohio:	Akron	6	2.6	1.0	1.6
	Cincinnati	7	3.4	0.9	2.1
	Cleveland	7	2.3	0.7	1.4
	Columbus	7	2.6	1.1	1.8
	Dayton	7	2.8	1.1	1.7
	Lorain	6	2.3	1.1	1.8
	Stuebenville	5	2.7	1.7	2.1
	Toledo	7	2.3	0.5	1.6
	Youngstown	7	2.4	1.1	1.8
Okla:	Cherokee Co.[a]	6	3.6	0.6	1.6
	Oklahoma City	7	3.6	1.4	2.3
	Tulsa	7	2.8	0.6	1.7
Ore:	Portland	6	2.0	0.2	0.9
Pa:	Clarion Co.[a]	5	2.2	1.5	1.8
	Lancaster	4	2.6	1.3	1.9
	Philadelphia	7	2.7	1.0	1.8
	Pittsburgh	7	2.9	1.1	1.9
P. R:	Guayanilla	7	3.3	0.8	1.9
	Ponce	7	3.2	0.7	1.8
	San Juan	6	3.2	0.7	1.9
R. I:	Providence	5	2.5	0.6	1.6
	Washington Co.[a]	6	2.9	1.0	1.8
S. C:	Columbia	7	2.6	1.0	1.6
	Richland Co.[a]	7	2.9	1.0	1.6
S. Dak:	Black Hills	6	3.9	1.1	2.2
	Sioux Falls[a]	6	2.5	0.8	1.3
Tenn:	Chattanooga	7	3.0	0.6	1.5
	Memphis	5	2.9	1.0	2.0
	Nashville	7	3.5	0.3	1.7
Tex:	Aransas Co.[a]	7	2.7	1.4	2.0
	Dallas	7	3.0	0.5	1.9
	El Paso	7	8.3	1.2	4.3
	Houston	5	1.9	0.9	1.4
	San Antonio	6	3.2	0.8	2.0
	Texarkana	5	3.8	0.8	1.9
	Waco	7	3.9	1.0	2.1
Utah:	Ogden	7	2.5	1.1	1.9
	Salt Lake City	7	2.6	1.3	2.0
Vt:	Burlington	6	2.6	0.5	1.5
	Orange Co.[a]	7	2.9	0.4	1.4
Va:	Danville	6	3.1	0.6	2.0
	Norfolk	7	3.2	1.4	2.2
	Shenandoah Pk.[a]	7	3.1	0.8	1.8
Wash:	Seattle	7	1.7	0.3	0.7
	Tacoma	6	1.9	0.3	0.9
W. Va:	Charleston	7	2.6	0.7	1.8
	Huntington	6	2.6	0.9	2.0
	Parkersburg	7	2.5	0.9	1.7
Wis:	Door Co.	6	2.4	1.0	1.6
	Eau Claire[a]	6	2.0	0.9	1.3
	Milwaukee	7	3.5	0.7	1.6
	Racine	7	2.7	0.8	1.4
	Superior	5	1.6	1.0	1.4
Wyo:	Cheyenne	6	4.0	0.8	2.2
	Yellowstone Pk.[a]	7	2.4	0.6	1.3
Network summary		1,025	5.7	0.2	1.78

[a] Nonurban stations.

FIGURE 3.—NATIONAL AIR SAMPLING NETWORK SAMPLING STATIONS, 1964

TABLE 4.—GROSS BETA ACTIVITY IN PRECIPITATION, NASN, FIRST QUARTER 1964

Station		January		February		March	
		pc/liter	mc/m³	pc/liter	mc/m³	pc/liter	mc/m³
Ala:	Montgomery	120	18	600	38	370	36
Calif:	Santa Maria	—	—	—	—	215	8
Fla:	Tampa	120	15	220	15	490	23
Ill:	Chicago (O'Hare)	—	—	—	—	1,520	11
La:	Lake Charles	120	12	290	18	500	43
Maine:	Caribou	—	—	—	—	450	26
Mass:	Nantucket	230	17	550	50	1,450	58
Mich:	Sault Ste Marie	340	22	580	24	—	—
Minn:	St. Cloud	—	—	—	—	500	20
Mo:	Columbia	—	—	—	—	650	29
N. Y:	Albany	430	26	—	—	570	41
N. C:	Hatteras	80	12	260	36	—	—
Ohio:	Cincinnati (Airport)	320	17	—	—	280	77
	Cincinnati (Gest St.)	270	19	—	—	320	57
Pa:	Philadelphia	480	40	620	54	—	—
S. C:	Charleston	170	27	200	30	520	49
	Greenville	200	28	215	26	240	41
Tenn:	Nashville	100	4	500	32	330	29
Va:	Sterling	210	16	620	47	520	29
Wash:	Tatoosh	340	71	450	39	580	73

3. Canadian Air Monitoring Program,[4] March 1964

Department of National Health and Welfare, Ottawa, Canada

As part of its Radioactive Fallout Study Program, the Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation. Twenty-four collection stations are located at airports (see figure 4), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in previous reports of the Department (*3–7*).

Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is cut from each filter and counted with a thin-end-window, gas flow Geiger-Mueller counter system, calibrated with a Sr^{90}–Y^{90} standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for March 1964 are given in table 5 and presented in conjunction with U. S. and Mexican data by an isogram map (figure 6).

[4] Data from *Radiation Protection Programs 4*:11–24, Radiation Protection Division, Canadian Department of National Health and Welfare (April 1964).

TABLE 5.—GROSS BETA ACTIVITY IN AIR, CANADA, MARCH 1964

[Average concentrations in pc/m³]

Station	Number of samples	Maximum	Minimum	Average
Calgary	27	3.6	0.2	1.4
Coral Harbour	31	2.6	0.5	1.1
Edmonton	31	2.5	0.4	1.2
Ft. Churchill	29	2.0	0.2	1.1
Ft. William	31	2.5	1.0	1.7
Fredericton	31	2.1	0.1	1.2
Goose Bay	31	2.0	0.3	1.3
Halifax	24	3.1	0.5	1.6
Inuvik	30	2.8	0.9	1.6
Montreal	31	2.5	0.6	1.7
Moosonee	29	2.3	0.9	1.5
Ottawa	29	2.2	0.6	1.5
Quebec	31	2.2	0.5	1.4
Regina	30	2.8	0.5	1.4
Resolute	31	2.4	0.2	1.0
St. John's, Nfld	30	3.0	0.1	1.1
Saskatoon	31	3.1	0.6	1.6
Sault Ste. Marie	31	2.9	0.6	1.7
Toronto	30	0.6	0.1	0.4
Vancouver	31	1.8	0.1	0.7
Whitehorse	31	3.9	0.1	1.6
Windsor	31	2.7	0.4	1.5
Winnipeg	31	2.3	0.7	1.5
Yellowknife	30	2.1	0.9	1.4
Network summary	722	3.9	0.1	1.3

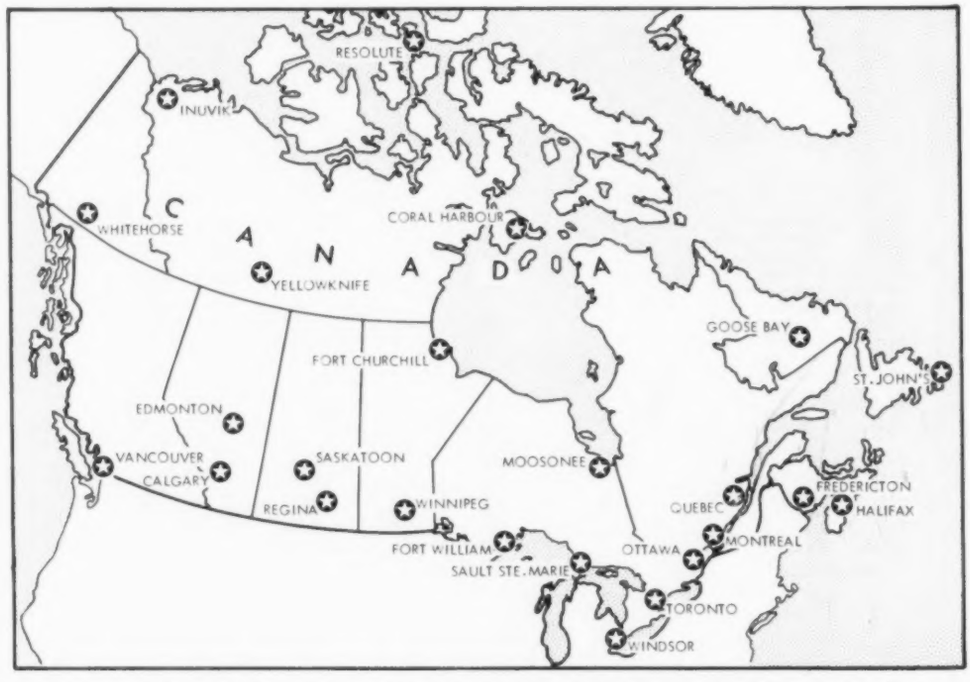

FIGURE 4.—CANADIAN AIR AND PRECIPITATION STATIONS, MARCH 1964

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is one month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are also added to selected samples according to the specific radionuclides to be determined. The samples are then filtered and the filtrate evaporated to near dryness. The filter paper containing insoluble matter is ignited together with the polyethylene liner at 450° C. The ash is combined with the soluble fraction, transferred to a glass planchet, evaporated under an infra-red lamp and then counted with a thin-end-window Geiger-Mueller counter calibrated with a Sr^{90}–Y^{90} source. Gross beta activities for March 1964 samples are given in table 6. Radionuclide analyses appear quarterly.

TABLE 6.—GROSS BETA ACTIVITY IN PRECIPITATION, CANADA, MARCH 1964

Station	Total beta activity	
	pc/liter	nc/m²
Calgary	964	8.1
Coral Harbour	[a]—	2.4
Edmonton	750	8.0
Ft. Churchill	347	3.1
Ft. William	660	11.4
Fredericton	403	36.7
Goose Bay	191	21.8
Halifax	161	22.9
Inuvik	582	3.0
Montreal	449	30.8
Moosonee	269	8.9
Ottawa	577	19.3
Quebec	371	41.5
Regina	483	5.6
Resolute	541	4.1
St. John's, Nfld	389	42.0
Saskatoon	485	3.3
Sault Ste. Marie	473	38.8
Toronto	462	41.3
Vancouver	788	76.5
Whitehorse	185	4.7
Windsor	722	58.9
Winnipeg	191	9.6
Yellowknife	777	4.7
Average	488	21.1

[a] Trace precipitation.

4. Mexican Air Monitoring Program March 1964

National Commission of Nuclear Energy

As part of its Radiological Protection Program (RPP), the Comisión Nacional de Energía Nuclear (CNEN) established the Radiation Surveillance Network of Mexico to provide a means for determining increased levels of radioactivity in air and precipitation.

The network has been gradually expanded to 17 stations (see figure 5). Twelve of the 17 stations are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí and Ensenada; Staff Members of the RPP operate the station at Mexico City while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Instituto de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air for 24 hours a day, 3 or 4 days a week, at the rate of approximately 1,200 cubic meters per day, through a high-efficiency glass fiber filter, 6″ x 8″, using high volume samplers. After each 24-hour period, the filter is removed and forwarded via air mail to the "Laboratorio de Estudios Sobre Contaminación Radiactiva", CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 or 4 days after collection is allowed for decay of radon and thoron daughters' natural radioactivity. Data are not extrapolated to time of collection.

The maximum, minimum and average fission product beta concentrations in surface air during March 1964 are presented in table 7.

FIGURE 5.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

TABLE 7.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES, MEXICO, MARCH 1964

[Concentrations in pc/m³]

Station	Number of samples	Maximum	Minimum	Average
Acapulco[a]	3	2.1	0.7	—
Ciudad Juárez	27	4.5	0.5	1.5
Chihuahua	17	5.0	0.6	2.4
Ensenada	13	2.8	0.7	1.4
Guadalajara	7	2.0	0.2	0.8
Guaymas[a]	0	—	—	—
La Paz	23	4.1	0.8	2.2
Matamoros[a]	0	—	—	—
Mazatlán	9	3.8	1.0	2.4
Mérida	13	2.3	0.5	1.2
Mexico City	15	1.6	0.1	0.5
Nuevo Laredo	6	2.6	0.5	1.3
San Luis Potosí	8	2.8	0.6	1.3
Tampico	6	1.7	0.3	0.7
Torreón	19	6.9	0.6	2.6
Tuxtla Gutiérrez[a]	0	—	—	—
Veracruz[a]	3	1.8	0.1	—

[a] Temporarily shut down.

5. Pan American Air Sampling Program March 1964

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by three countries in South America under the auspices of a collaborative program developed by the Pan American Health Organization and the Public Health Service (PHS) for assisting countries of the Americas in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network.

The three air sampling stations included in the program are operated by the technical staff of the Ministry of Health in each country. The station in Santiago, Chile is operated by the Occupational Health Service; in Lima, Peru by the Institute of Occupational Health; and in Caracas, Venezuela by the Venezuelan Institute for Scientific Investigations. The Caracas station began operation in November 1962 and the other two stations were started the following month.

The March 1964 air monitoring results from the three participating countries are given in table 8. The Caracas station is shown on the gross beta concentration isogram map (figure 6) and its March average, 1.0 pc/m³ (after adjustment by the RSN intercalibration factor[5]) was used in estimating the position of the 1.0 pc/m³ isogram.

[5] The RSN factor is 1.28.

TABLE 8.—GROSS BETA ACTIVITY IN AIR, MARCH 1964

[Concentrations in pc/m³]

Sampling stations	No. of samples	Maximum	Minimum	Average [a]
Caracas, Venezuela	23	1.30	<0.10	0.78
Lima, Peru	0	—	—	—
Santiago, Chile	16	0.16	<0.10	<0.10

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed in front of the average.

6. Gross Beta Activity in Air, North America, March 1964

Beginning with January 1963 data, monthly average concentrations of airborne gross beta activity in Canada and the United States have been presented in combined form as isogram maps of most of North America.[6] The data from the Radiation Surveillance Network and the Canadian Air Network were adjusted to each other by means of an intercalibration factor derived by Lockhart and Patterson (*8*).

With the formation of the Mexican Air monitoring program, new intercalibration ratios were determined, this time including the Canadian Network, Radiation Surveillance Network, National Air Sampling Network, the HASL 80th Meridian Network, and the Mexican Network (*9*). The new intercalibration factors include some changes in standardization in both the RSN and the Canadian Air Network, effective September 1963. The intercalibration fac-

[6] The January 1963 through February 1964 isogram maps were published in the May 1963 through June 1964 issues of *Radiological Health Data*.

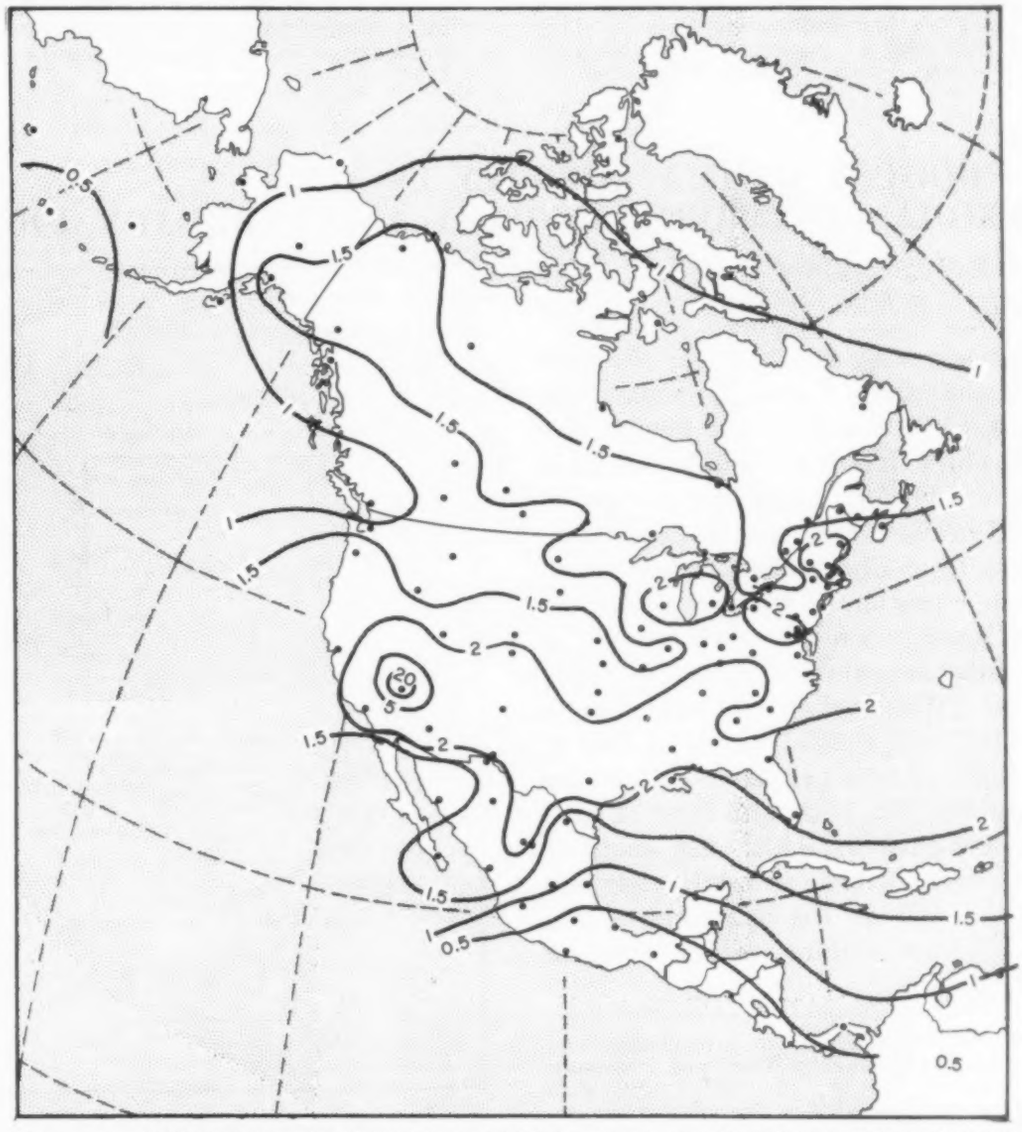

FIGURE 6.—ISOGRAMS OF AVERAGE GROSS BETA CONCENTRATIONS IN AIR THROUGHOUT NORTH AMERICA, MARCH 1964

tors are, therefore, not the same as were previously used.

Figure 6 shows the March 1964 activity in air throughout North America based on the data from the Canadian Air Monitoring Program, the Radiation Surveillance Network and Mexican Air Monitoring program. An intercalibration factor of 1.28 was applied to the RSN data and the Mexican data were multiplied by 0.81 in order to adjust them to Canadian data.

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FISSION PRODUCT GAMMA ACTIVITY IN AIR— 80TH MERIDIAN NETWORK, JANUARY AND FEBRUARY 1964

Health and Safety Laboratory[1]
Atomic Energy Commission

Fourteen air sampling stations near the 80th Meridian (West) from Thule, Greenland, to Punta Arenas, Chile, make up the Health and Safety Laboratory (HASL) 80th Meridian Network (figure 1). An additional station at Mauna Loa, Hawaii, is included for comparing data with that from Chacaltaya, Bolivia; both are at a high elevation and their respective latitudes North and South are nearly equal.

Air particulates are sampled on 8-inch-diameter polystyrene (Microsorban) filters, drawing air through the filters, continuously at a rate of about 1400 cubic meters per day. Filters are changed on the 1st, 8th, 15th, and 22nd of each month and forwarded to HASL for analysis. A total gamma count is made approximately two weeks after the end of the sampling period using an 8 x 4-inch sodium iodide (thallium activated) crystal.

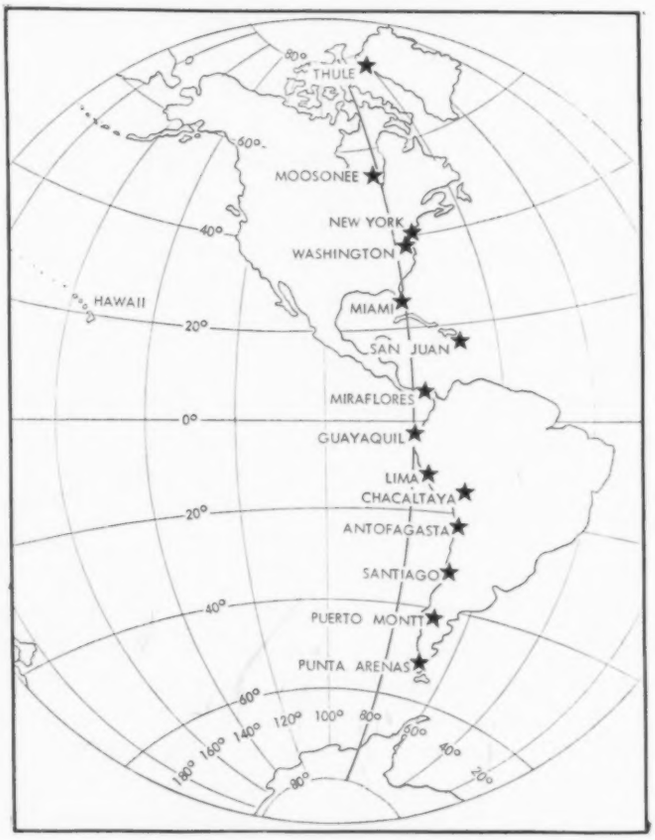


FIGURE 1.—80TH MERIDIAN NETWORK SAMPLING STATIONS

[1] This report was developed from information and data in the March 1963, January 1964, and February 1964 monthly reports of: W. R. Collins, Jr., *80th Meridian Network, Results of Air Sampling Measurements*, Health and Safety Laboratory, U.S. Atomic Energy Commission, New York, N.Y. 10014.

The results of total gamma activity determinations in weekly ground level air filter samples taken at 80th Meridian stations during January and February 1964 are listed in tables 1 and 2, together with average monthly activity concentrations calculated for each site. The average monthly activities are also plotted in figure 2 as an activity—latitude profile.

The monthly averages for all of the northern sites were 0.77 and 0.85 γ/min/m^3 for January and February, respectively. The corresponding averages in the Southern Hemisphere were 0.055 and 0.051 γ/min/m^3. These averages are about one-tenth of the averages for January and February 1963.

TABLE 1.—GAMMA ACTIVITY IN SURFACE AIR, 80TH MERIDIAN NETWORK, JANUARY 1964

[Activity in gamma photons/min/m^3]

Station latitude, elevation	January sampling periods				January average
	1–7	8–14	15–21	22–31	
Thule, Greenland 77° N, 259 m	0.948	1.00	0.845	0.986	0.948
Moosonee, Canada 51° N, 10 m	0.871	0.689	0.657	0.704	0.728
New York, N. Y. 41° N, 38 m	0.580	0.430		0.421	0.485
Washington, D. C. 39° N, 82 m	0.722	0.481	0.769	0.865	0.728
Miami, Fla. 26° N, 4 m	1.35	0.713	1.36	2.04	1.42
Mauna Loa, Hawaii 19° N, 3394 m	0.416	0.931	0.809	1.08	0.838
San Juan, P. R. 18° N, 10 m	0.312	0.140	0.275	1.82	0.736
Miraflores, Canal Zone 9° N, 10 m	0.310	0.305	0.344	0.477	0.371
Guayaquil, Ecuador 0°–08′ S, 7 m	0.0405	0.0384	0.0437	0.0600	0.0457
Lima, Peru 12° S, 30 m	0.0757	0.0923	0.0814	0.101	0.0876
Chacaltaya, Bolivia 17° S, 5220 m	0.0341	0.0183	0.0472	0.0280	0.0315
Antofagasta, Chile 24° S, 519 m	0.0643	0.0545	0.141	0.0807	0.0848
Santiago, Chile 33° S, 5 m	0.0498	0.0817	0.0950	0.0564	0.0693
Puerto Montt, Chile 41° S, 5 m	0.0473	0.0460	0.0580	0.0279	0.0448
Punta Arenas, Chile 53° S, 3 m	0.0110	0.0255	0.0364	0.0211	0.0235

TABLE 2.—GAMMA ACTIVITY IN SURFACE AIR, 80TH MERIDIAN NETWORK, FEBRUARY 1964

[Activity in gamma photons/min/m^3]

Station latitude, elevation	February sampling periods				February average
	1–7	8–14	15–21	22–31	
Thule, Greenland 77° N, 259 m	1.03	0.596	0.732	0.805	0.791
Moosonee, Canada 51° N, 10 m	0.628	0.854	0.380	0.797	0.665
New York, N. Y. 41° N, 38 m	0.550		0.531	1.05	0.710
Washington, D. C. 39° N, 82 m	0.885	0.884	0.706	0.850	0.833
Miami, Fla. 26° N, 4 m	1.49	1.59	1.62	1.32	1.50
Mauna Loa, Hawaii 19° N, 3394 m	1.91	1.08	1.22	1.62	1.48
San Juan, P. R. 18° N, 10 m	0.614	0.0929	0.524	0.495	0.432
Miraflores, Canal Zone 9° N, 10 m	0.598	0.501	0.540	0.629	0.567
Guayaquil, Ecuador 0°–08′ S, 7 m	0.0843	0.0946	0.0562	0.0917	0.0822
Lima, Peru 12° S, 30 m	0.0656	0.0496	0.0784	0.0912	0.712
Chacaltaya, Bolivia 17° S, 5220 m	0.00429	0.0156	0.0105	0.0311	0.0159
Antofagasta, Chile 24° S, 519 m	0.0463	0.0735	0.0620	0.0336	0.0532
Santiago, Chile 33° S, 5 m	0.0584	0.0649	0.0543	0.0681	0.0614
Puerto Montt, Chile 41° S, 5 m	0.0380	0.0448	0.0480	0.0486	0.0450
Punta Arenas, Chile 53° S, 3 m	0.0147	0.0283	0.0395	0.0240	0.0266

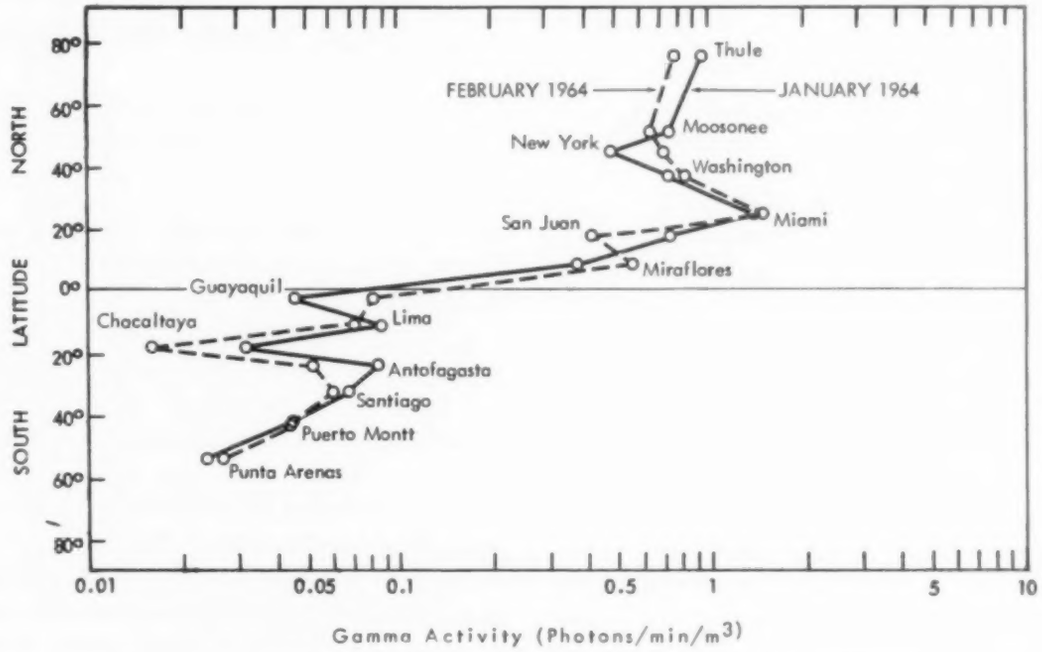


FIGURE 2.—PROFILE OF SURFACE AIR GAMMA ACTIVITY, JANUARY AND FEBRUARY 1964

Section II—Milk and Food

MILK SURVEILLANCE

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as being biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples which are representative of milk consumption in any area can be readily obtained.

1. Pasteurized Milk Network, March 1964

Division of Radiological Health and Division of Environmental Engineering and Food Protection, Public Health Service

The Public Health Service pasteurized milk radionuclide surveillance program had its origin in a raw milk monitoring network (*1*) established by the Service in 1957. One of the primary objectives of this network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. The present network, which consists of 63 stations, has at least one station in every State, the Canal Zone, and Puerto Rico.

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each of these stations. Composites of the samples are preserved with formaldehyde and are sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern Radiological Health Laboratories (NERHL) for analysis. Gamma analyses for iodine–131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pc/liter are immediately telephoned to State health officials for possible public health action. Analytical results are normally available 6 to 7 weeks after collection; publication in *RHD* follows 3 to 4 months after sample collection.

Sampling and Compositing Procedures

The method specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations the composited sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected twice a week at nearly all stations and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week.

Analytical Errors

Iodine–131, cesium–137, and barium–140 concentrations are determined by gamma scintillation spectroscopy.[1] After gamma scanning, samples from two consecutive weeks are composited and analyzed radiochemically for strontium–89 and strontium–90. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation on a percentage basis is relatively high. The variation is dependent upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 to 50 minutes for low background beta determinations are used. Table 1 shows the approximate total analytical error (including counting error) associated with radionuclide concentrations in milk. These errors were determined by comparing results of a large number of analyses. The ± 2 standard deviations (2σ) about the measured concentration correspond to a 95 percent centainty that the true concentration is within this range. The minimum detectable concentration is defined as the measured concentration at which the two-standard-deviation analytical error is equal to the measurement. Accordingly, the minimum detectable concentrations in units of pc/liter are Sr^{89}, 5; Sr^{90}, 2; Cs^{137}, 10; Ba^{140}, 10; and I^{131}, 10. At these levels and below, the counting error comprises nearly all of the analytical error.

TABLE 1.—ANALYTICAL ERRORS ASSOCIATED WITH ESTIMATED CONCENTRATIONS FOR SELECTED RADIONUCLIDES IN MILK

Nuclide	Estimated concentration (pc/liter)	Error [a] (pc/liter)	Estimated concentration (pc/liter)	Error [a] (percent of concentration)
Iodine-131	0 to 100	±10	100 or greater	±10%
Barium-140	0 to 100	±10	100 or greater	±10%
Cesium-137	0 to 100	±10	100 or greater	±10%
Strontium-89	0 to 50	±5	50 or greater	±10%
Strontium-90	0 to 20	±2	20 or greater	±10%

[a] Two standard deviations (2σ).

[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium–140 analysis.

Calcium analyses at SERHL are done by an ion exchange and permanganate titration method while at NERHL and SWRHL an ethylenediaminetetraacetic acid (EDTA) method is used. Stable potassium concentrations are estimated from the potassium–40 concentrations[2] determined from the gamma spectrum.

Data Presentation

Table 2 presents summaries of the analyses for March 1964 (March 1–28, 1964). Although not shown in table 2, the iodine–131 and barium–140 monthly average concentrations in milk were less than 10 pc/liter. When a radionuclide is reported by a laboratory as being below the minimum detectable concentration, one-half the minimum detectable value is used as the best approximation in calculating the monthly average. Beginning with October 1963 data, however, zero is used as the best approximation to a nondetectable concentration of iodine–131 or barium–140. A similar procedure is used for the network average.

Figures 1 and 2 are isogram maps showing the estimated strontium–90 and cesium–137 concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. The isograms were developed by arbitrary interpolation between values for the individual stations. Additional modifications to the isograms are made according to available information on milksheds.

In order to develop the distribution of the network's stations versus radionuclide concentrations in milk, table 3 has been prepared using monthly averages shown in table 2.

Continuing the practice followed in previous issues of *RHD*, the average monthly strontium–90 concentrations in pasteurized milk from 16 selected cities in the sampling program are presented in figure 3. Each graph shows the strontium–90 concentrations in milk from one city in each of the four U. S. Bureau of Census regions. This method of selection permits graphic presentation of data for each city in the network three times a year. The last column in table 2 shows the most recent issue in which a graph of the strontium–90 concentration was given for each station.

[2] The conversion factor is 1.18×10^{-3} g K/pc K^{40}.

TABLE 2.—STABLE ELEMENT AND RADIONUCLIDE CONCENTRATIONS IN PASTEURIZED MILK, MARCH 1964 [a]

[Average radioactivity concentrations in pc/liter]

Sampling locations		Calcium (g/liter)		Potassium (g/liter)		Strontium-89		Strontium-90		Cesium-137		Last Sr^{89} graph in *RHD* (1964)
		First quarter	Avg. for month	First quarter	Avg. for month	First quarter	Avg. for month	First quarter	Avg. for month	First quarter	Avg. for month	
Ala:	Montgomery	1.19	1.12	1.5	1.5	<5	<5	24	25	100	95	June
Alaska:	Palmer	1.16	1.16	1.5	1.5	10	5	23	18	160	140	July
Ariz:	Phoenix	1.18	1.18	1.5	1.5	<5	<5	4	4	25	30	May
Ark:	Little Rock	1.18	1.14	1.5	1.5	<5	5	43	50	165	175	July
Calif:	Sacramento	1.25	1.26	1.6	1.5	<5	<5	11	12	65	70	April
	San Francisco	1.23	1.26	1.5	1.4	<5	<5	13	14	75	70	June
Canal Zone:	Cristobal	1.13	1.11	1.6	1.6	<5	<5	6	6	50	50	July
Colo:	Denver	1.23	1.22	1.6	1.5	<5	5	19	19	90	100	April
Conn:	Hartford	1.15	1.14	1.6	1.6	<5	<5	23	24	185	190	April
Del:	Wilmington	1.21	1.23	1.6	1.6	<5	<5	21	22	150	160	May
D. C:	Washington	1.17	1.13	1.6	1.6	<5	<5	18	18	105	110	June
Fla:	Tampa	1.21	1.14	1.5	1.5	<5	<5	15	14	200	225	May
Ga:	Atlanta	1.21	1.16	1.6	1.5	<5	<5	35	36	160	180	June
Hawaii:	Honolulu	1.18	1.15	1.6	1.6	<5	<5	11	11	80	85	July
Idaho:	Idaho Falls	1.19	1.22	1.6	1.5	5	<5	27	10	220	215	May
Ill:	Chicago	1.18	1.18	1.6	1.6	<5	<5	21	20	145	150	June
Ind:	Indianapolis	1.22	1.22	1.6	1.6	<5	<5	22	20	120	130	April
Iowa:	Des Moines	1.22	1.24	1.5	1.4	<5	5	27	26	110	110	May
Kans:	Wichita	1.21	1.20	1.5	1.4	10	10	23	24	80	85	July
Ky:	Louisville	1.18	1.14	1.6	1.5	<5	<5	32	34	125	130	May
La:	New Orleans	1.22	1.17	1.5	1.5	<5	<5	54	64	165	190	July
Maine:	Portland	1.20	1.22	1.6	1.6	<5	<5	31	30	220	215	May
Md:	Baltimore	1.17	1.12	1.5	1.5	<5	<5	20	22	115	125	May
Mass:	Boston	1.20	1.21	1.6	1.6	<5	<5	32	28	265	270	June
Mich:	Detroit	1.19	1.20	1.6	1.6	<5	<5	19	18	135	135	April
	Grand Rapids	1.21	1.22	1.5	1.6	<5	<5	22	19	145	150	May
Minn:	Minneapolis	1.18	1.22	1.6	1.5	10	20	35	30	190	195	June
Miss:	Jackson	1.26	1.26	1.5	1.5	5	<5	41	48	125	135	April
Mo:	Kansas City	1.22	1.28	1.5	1.4	5	5	28	27	100	100	April
	St. Louis	1.20	1.19	1.5	1.5	5	<5	23	24	100	105	July
Mont:	Helena	1.22	1.24	1.5	1.5	10	10	31	31	235	235	July
Nebr:	Omaha	1.21	1.26	1.5	1.4	5	<5	25	26	105	110	May
Nev:	Las Vegas	1.24	1.21	1.6	1.5	<5	<5	15	13	95	100	June
N. H:	Manchester	1.22	1.25	1.7	1.6	<5	<5	32	28	260	255	May
N. J:	Trenton	1.19	1.20	1.6	1.6	5	<5	18	18	140	150	April
N. Mex:	Albuquerque	1.19	1.22	1.5	1.4	<5	5	12	11	60	60	July
N. Y:	Buffalo	1.16	1.17	1.6	1.6	<5	<5	20	20	170	175	April
	New York	1.16	1.18	1.6	1.7	<5	<5	25	22	190	195	June
	Syracuse	1.18	1.16	1.6	1.6	<5	<5	22	20	170	180	July
N. C:	Charlotte	1.22	1.18	1.5	1.5	<5	<5	31	36	115	120	July
N. Dak:	Minot	1.21	1.24	1.5	1.4	15	30	58	39	160	155	May
Ohio:	Cincinnati	1.21	1.20	1.6	1.6	<5	<5	24	25	125	120	April
	Cleveland	1.21	1.19	1.6	1.6	<5	<5	22	23	135	145	July
Okla:	Oklahoma City	1.18	1.12	1.6	1.5	<5	<5	25	26	90	90	June
Ore:	Portland	1.24	1.28	1.5	1.4	5	<5	27	26	155	150	April
Pa:	Philadelphia	1.21	1.22	1.6	1.5	<5	<5	20	20	145	150	July
	Pittsburgh	1.19	1.19	1.6	1.6	<5	<5	28	28	170	175	July
P. R:	San Juan	1.16	1.12	1.6	1.6	<5	<5	12	13	70	85	July
R. I:	Providence	1.18	1.18	1.6	1.6	<5	<5	25	25	185	185	May
S. C:	Charleston	1.18	1.12	1.5	1.5	<5	<5	34	34	135	140	April
S. Dak:	Rapid City	1.19	1.20	1.5	1.5	10	10	38	30	175	175	June
Tenn:	Chattanooga	1.23	1.20	1.5	1.4	5	<5	38	44	145	155	June
	Memphis	1.21	1.14	1.5	1.6	<5	<5	32	36	90	95	May
Tex:	Austin	1.17	1.12	1.6	1.5	<5	<5	10	11	45	45	June
	Dallas	1.19	1.14	1.6	1.6	<5	<5	22	24	85	85	April
Utah:	Salt Lake City	1.21	1.16	1.5	1.4	5	10	27	26	215	235	July
Vt:	Burlington	1.18	1.18	1.6	1.6	<5	<5	26	23	210	210	April
Va:	Norfolk	1.18	1.14	1.6	1.6	<5	<5	20	22	105	110	April
Wash:	Seattle	1.21	1.23	1.5	1.5	10	10	21	24	120	125	June
	Spokane	1.24	1.26	1.6	1.5	5	5	33	24	145	140	April
W. Va:	Charleston	1.18	1.14	1.5	1.5	<5	<5	26	28	110	110	June
Wis:	Milwaukee	1.22	1.22	1.7	1.8	<5	<5	19	18	160	160	May
Wyo:	Laramie	1.18	1.23	1.5	1.4	10	15	21	19	115	130	May
Network average		1.20	1.19	1.6	1.5	<5	<5	24.8	24.3	136	141	Nov. 63

[a] The monthly average iodine-131 and barium-140 concentration at each station was <10 pc/liter.

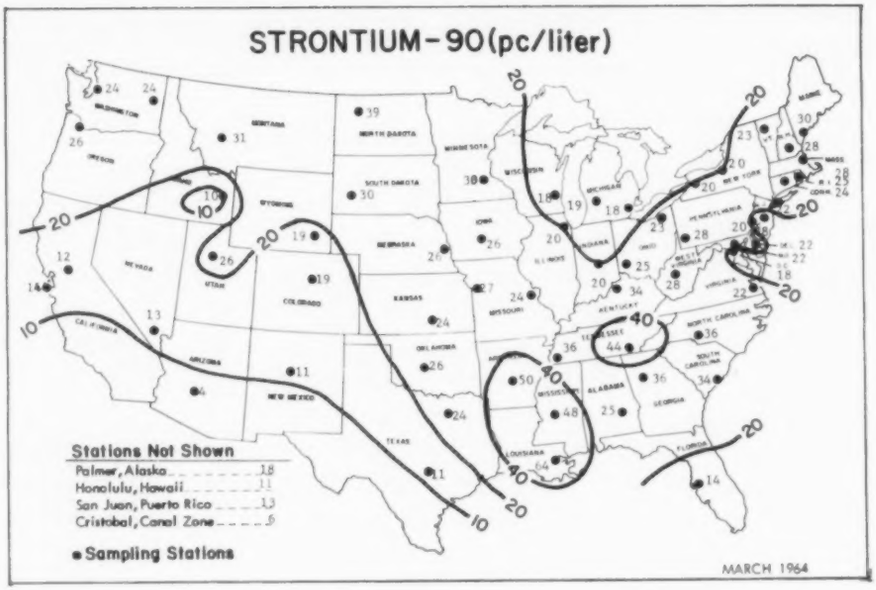


FIGURE 1.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK, MARCH 1964

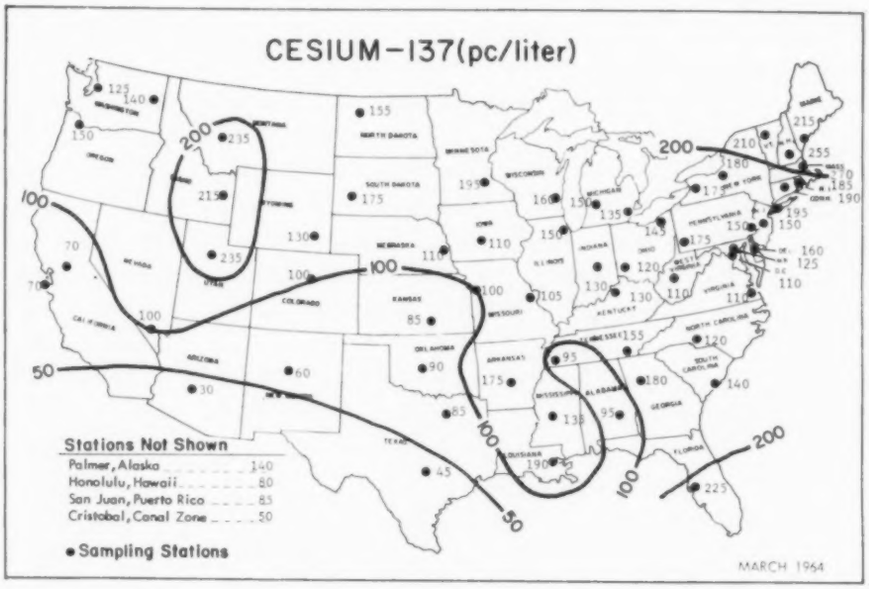


FIGURE 2.—CESIUM-137 CONCENTRATIONS IN PASTEURIZED MILK, MARCH 1964

TABLE 3.—DISTRIBUTION OF SAMPLING STATIONS IN VARIOUS RANGES OF RADIONUCLIDE CONCENTRATIONS IN MILK, MARCH 1964

Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations
<5	48	<1–9	2	<10	63	<5–45	2	<10	63
5	7	10–14	9			50–95	11		
10	5	15–19	8			100–145	22		
15	1	20–24	17			150–195	20		
20	1	25–29	13			200–245	6		
25	0	30–34	6			250–295	2		
30	1	35–39	4						
		40–69	4						
Total	63	Total	63	Total	63	Total	63	Total	63

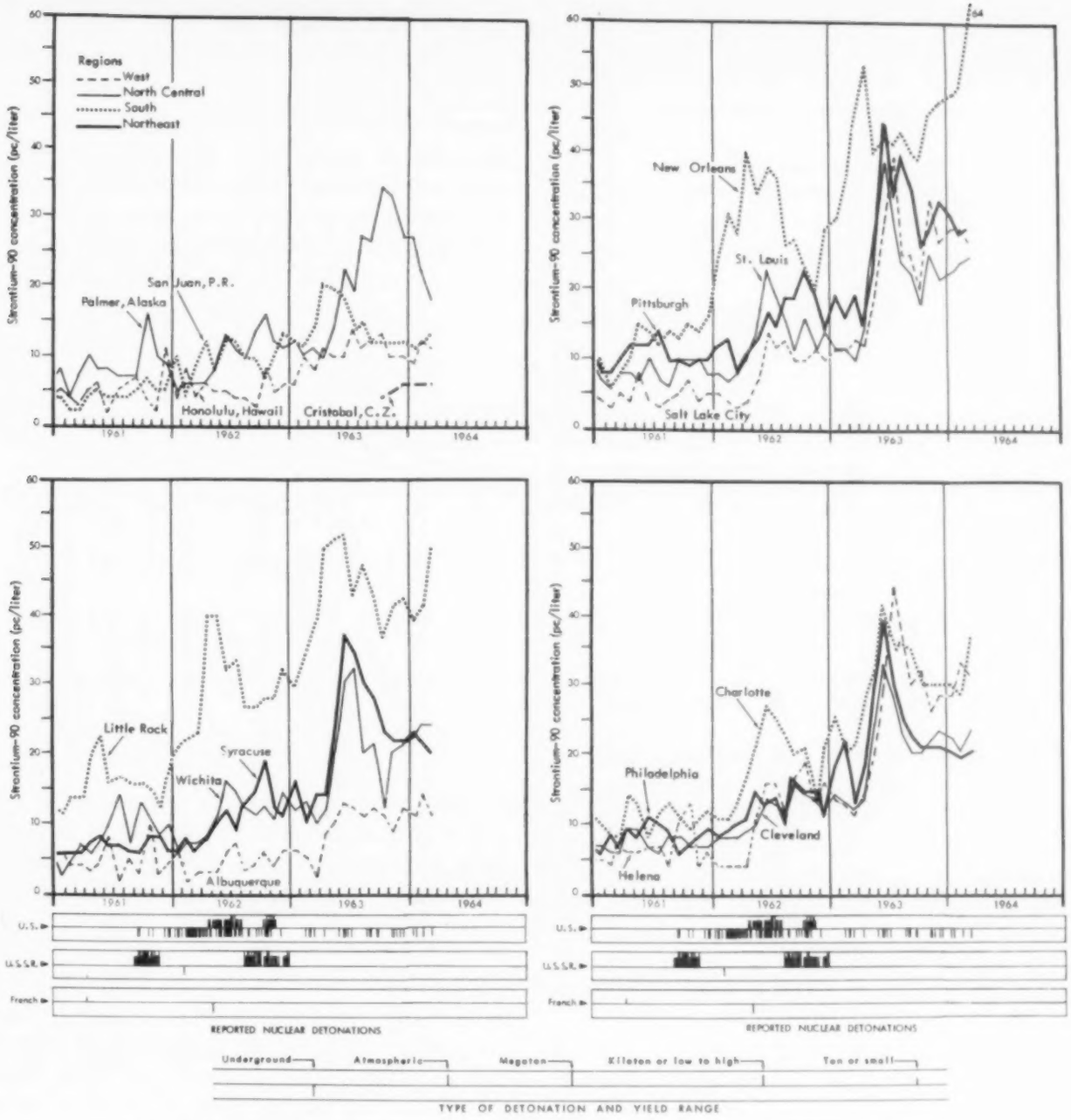


FIGURE 3.—STRONTIUM-90 IN PASTEURIZED MILK, 1961–MARCH 1964

Monthly network maximum, minimum, and average radionuclide levels in milk summarized in table 4 are helpful in showing the variability of results about the average and trends of the U. S. milk data since March 1960. When strontium–89 concentrations have been detectable, the ratio of the network maximum to the network average has ranged from 2.5 to 12.0 but was less than 4.0 a majority of the time. For iodine–131 the ratio of maximum to average concentration has been somewhat higher, ranging from 2.4 to 16.5. The strontium–90 maximum to average ratio has exceeded 3.0 only three times since March 1960. Furthermore, the ratio

TABLE 4.—NETWORK MONTHLY MAXIMUM, MINIMUM, AND AVERAGE RADIONUCLIDE CONCENTRATIONS IN MILK, MARCH 1960–MARCH 1964

[Concentrations in pc/liter]

Year and month	Number of stations in the network	Strontium-89			Strontium-90			Iodine-131			Cesium-137		
		Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
1960													
Mar	5	10	[a] 0	0	8	3	6	0	0	0	[b] —	[b] —	[b] —
Apr	18	20	0	5	16	2	8	0	0	0	45	<10	20
May	19	5	0	0	15	4	8	0	0	0	50	<10	25
June	33	0	0	0	18	2	9	0	0	0	40	<10	20
July	45	10	0	0	18	2	9	0	0	0	70	<10	15
Aug	57	0	0	0	14	1	7	0	0	0	80	<10	10
Sept	58	0	0	0	16	2	8	0	0	0	85	<10	5
Oct	58	0	0	0	12	2	7	0	0	0	75	<5	5
Nov	58	0	0	0	14	1	7	0	0	0	80	<5	10
Dec	58	0	0	0	14	2	8	0	0	0	50	<5	5
1961													
Jan	58	0	0	0	12	2	7	0	0	0	40	<5	<5
Feb	58	0	0	0	14	1	6	0	0	0	25	<5	5
Mar	58	0	0	0	14	2	7	0	0	0	40	<5	5
Apr	58	0	0	0	20	3	8	0	0	0	90	<5	10
May	58	0	0	0	22	4	9	0	0	0	110	<5	15
June	58	0	0	0	16	2	9	0	0	0	130	<5	25
July	58	0	0	0	17	2	8	0	0	0	70	<5	15
Aug	58	0	0	0	16	2	8	0	0	0	85	<5	10
Sept	[c] 59	30	<5	10	16	3	8	[d] (340)	10	(100)	100	<5	15
Oct	60	170	<5	40	17	3	9	340	20	100	75	<5	15
Nov	60	180	<5	55	33	2	9	210	20	60	90	<5	10
Dec	60	205	<5	35	17	2	9	50	<10	10	40	<5	10
1962													
Jan	61	300	<5	25	24	2	8.5	20	<10	<10	50	<5	9
Feb	61	365	<5	31	31	2	8.7	20	<10	<10	65	<5	9
Mar	61	315	<5	35	28	3	8.6	20	<10	<10	100	<5	16
Apr	61	380	<5	63	40	3	12.0	10	<10	<10	135	<5	25
May	61	220	5	60	40	2	13.9	220	<10	21	155	<5	38
June	61	215	5	71	40	3	17.4	350	<10	30	120	<5	61
July	62	145	10	53	36	2	15.6	580	<10	38	160	20	67
Aug	62	150	5	50	27	2	14.1	330	<10	20	155	15	65
Sept	62	175	<5	44	28	2	14.5	730	<10	62	140	10	54
Oct	62	150	5	56	29	2	16.0	270	<10	61	130	15	58
Nov	62	200	10	57	28	4	14.6	170	10	70	140	15	62
Dec	62	195	15	50	33	4	14.6	330	<10	51	115	20	66
1963													
Jan	62	170	<5	34	30	3	15.4	40	<10	14	110	20	66
Feb	62	270	<5	33	36	3	15.4	30	<10	<10	135	25	72
Mar	62	365	<5	44	44	2	15.8	20	<10	<10	165	20	70
Apr	62	250	<5	59	53	4	19.1	20	<10	<10	185	15	79
May	62	235	20	95	56	6	26.5	<10	<10	<10	210	20	107
June	62	320	10	106	62	5	32.0	10	<10	<10	270	10	149
July	62	195	10	77	67	3	31.4	<10	<10	<10	380	15	163
Aug	62	125	5	47	58	3	28.1	<10	<10	<10	380	25	150
Sept	62	100	<5	31	56	4	25.6	<10	<10	<10	310	30	128
Oct	63	75	<5	18	54	2	23.1	0	0	0	285	30	115
Nov	63	25	<5	9	50	4	24.8	0	0	0	280	30	125
Dec	63	20	<5	5	60	3	24.6	0	0	0	280	25	130
1964													
Jan	63	10	<5	<5	68	4	24.9	0	0	0	265	20	134
Feb	63	10	<5	<5	67	5	25.3	0	0	0	260	20	135
Mar	63	20	<5	<5	64	4	24.3	0	0	0	270	30	141

[a] Zero was used in calculations and indicates no detectable activity.
[b] Dash indicates no analysis performed.
[c] Only 17 stations collected samples during the latter part of September.
[d] Values in parentheses are estimates based upon data from the next month.

has dropped below 1.9 only infrequently. Of the four nuclides for which determinations are being made, the monthly maximum strontium–90 concentrations have generally not varied from the network average by as large a factor as the other nuclides. Before 1962, the ratio of network maximum to average cesium–137 monthly average concentrations ranged from 2.0 to 17.0. In 1962 this ratio ranged to 7.2 and more recently in 1963 and 1964 has not exceeded 2.5. This decrease may be explained by the generally rising levels throughout the network since 1962.

2. Indiana Milk Network, March 1964

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radiological analysis in September 1961. Indiana was geographically divided into five major milksheds, and one large dairy within each milkshed was selected as a sampling station (figure 4).

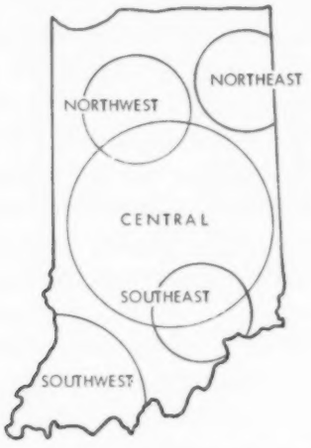


FIGURE 4.—INDIANA MILK SAMPLING LOCATIONS

The milk samples are routinely analyzed for iodine–131, cesium–137, barium–140, strontium–89 and strontium–90. Until August 1963, analyses for the gamma emitters iodine–131, cesium–137 and barium–140 were conducted on a weekly basis, except when iodine–131 exceeded 100 pc/liter, at which times the frequency of sampling was increased. Because of continued low concentrations of the short-lived gamma emitters, the sampling frequency was reduced in August 1963 to once per month for the northeast, southeast and southwest milksheds. Strontium–89 and strontium–90 analyses are performed monthly for each station.

An ion exchange analytical procedure (*2*) is employed for strontium–89 and strontium–90 analyses. Minimum detectable levels for strontium–89 and strontium–90 are about 5 and 1 pc/liter, respectively. A 512-channel pulse height analyzer and shielded 4 x 4-inch sodium iodide crystal are used for the gamma analysis of iodine–131, cesium–137, and barium–140. The lower limit of detectability for both iodine–131 and barium–140 is 5 pc/liter. Cesium–137 analyses are subject to a 6 percent error at the 100 pc/liter level.

The monthly averages of the data obtained for the individual sampling stations and the State averages are reported in table 5. The State average is an arithmetic average of the station values.

TABLE 5.—RADIONUCLIDES IN INDIANA MILK, MARCH 1964 [a]

[Radionuclide concentrations in pc/liter]

Sampling location	Calcium (g/liter)	K^{40}	Sr^{90}	Cs^{137}
Northeast	1.20	1240	19	115
Southeast	1.20	1250	25	105
Central	1.18	1300	21	110
Southwest	1.17	1290	27	110
Northwest	1.18	1270	25	125
Average	1.17	1280	23	115

[a] The monthly average iodine-131, barium-140, and strontium-89 concentration at each station was zero.

3. New York Milk Network, January 1964

Division of Environmental Health Services,
State of New York Department of Health

Milk samples collected routinely from six cities—Albany, Buffalo, Massena, Newburgh, New York City, and Syracuse (figure 5)—are analyzed for their radionuclide content by the New York State Deportment of Health. Pasteurized milk samples are collected daily and composited weekly for the determination of strontium–89, strontium–90, iodine–131, cesium–137 and barium-lanthanum–140 at all

FIGURE 5.—NEW YORK MILK SAMPLING LOCATIONS

stations except Massena, where samples are composited bi-weekly, and at New York City where one daily milk sample representing the total milk supply for that day is obtained and analyzed once a week. Samples are obtained from processing plants except at Albany, where the daily sample is obtained from a marketing point. During periods when cows are no longer on stored feed, the sample from Albany is analyzed daily for iodine–131. In the event that any city reports iodine–131 concentrations exceeding 100 pc/liter, increased surveillance is undertaken.

A matrix method (*3*) is used for the analysis of spectral data to determine the concentrations of gamma-emitting nuclides in milk. With this method, the individual nuclide contributions to the gamma spectrum are separated by solution of simultaneous equations describing the spectral interferences.

The analytical procedure for strontium–89 and strontium–90 is based on ion exchange methods. Cations (including radiostrontium) are eluted from the ion exchange resin with sodium chloride solution, strontium isotopes are gathered by means of sodium carbonate, isolated by means of ethylenediaminetetraacetic acid (EDTA), and radiostrontium is counted with a low background beta counter having an 0.8 mg/cm^2 window. The strontium–90 portion is differentially estimated by a second count 40 hours later to determine the rate of ingrowth of its daughter product yttrium–90. The monthly average radionuclide concentrations in milk are shown in table 6.

TABLE 6.—RADIONUCLIDES IN NEW YORK MILK, JANUARY 1964 [a]

[Average concentrations in pc/liter]

Sampling location	Strontium-89	Strontium-90	Cesium-137
Albany	5	20	125
Buffalo	6	13	109
Massena	4	28	204
Newburgh	7	23	131
New York City	6	25	133
Syracuse	6	19	123
Average	6	21	138

[a] The monthly average I^{131} and Ba-La^{140} at each station was <20 pc/liter. Ba-La^{140} refers to the sum of these nuclides in equilibrium.

4. Pennsylvania Milk Network, December 1963—March 1964

Bureau of Environmental Health, Pennsylvania Department of Health

Samples of pasteurized milk are routinely collected from 10 major milk consumption areas throughout Pennsylvania (figure 6). Two samples per week are collected in Philadelphia and Pittsburgh, while weekly composite samples are collected from the other eight stations. At each sampling location subsamples are collected from the major dairies supplying the area and are composited in proportion to the amount of milk processed by each dairy. This composite sample is then sent to the Radiation Laboratory of the Division of Occupational Health in Harrisburg, where the weekly samples are combined for monthly analyses. Iodine–131 analyses were carried out from September 1962 through February 1963, when concentrations fell to non-detectable levels. Since April 1963, samples have been analyzed for strontium–90. The gamma analyses of these samples for potassium–40, iodine–131, cesium–137, and barium–140-lanthanum–140 were begun in March 1964.

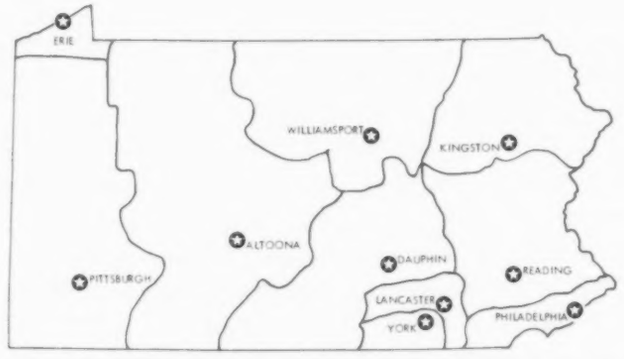


FIGURE 6.—PENNSYLVANIA MILK SAMPLING STATIONS AND MILK CONSUMPTION AREAS

The chemical separation technique for strontium–90 is essentially an ion exchange method described by Porter, *et al.* (*2*). One liter of milk is passed through an ion exchange column; yttrium–90 is eluted from the resin and is counted in an automatic low background proportional counter.

Samples of whole milk amounting to 3.5 liters are analyzed for gamma emitters with a 4-inch sodium iodide crystal, which is contained in a large steel shield. A multichannel analyzer records the spectra, and the radionuclide content

is quantitatively determined by the matrix method.

The monthly average strontium–90 levels in pasteurized milk are shown in table 7 and the monthly average results for gamma emitters are shown in table 8.

TABLE 7.—STRONTIUM-90 IN PENNSYLVANIA MILK, DECEMBER 1963–MARCH 1964

[Concentrations in pc/liter]

Sampling location	December	January	February	March
Altoona	14	21	20	23
Dauphin	16	18	15	27
Erie	18	13	21	24
Kingston	16	10	22	28
Lancaster	18	15	18	21
Philadelphia	17	20	16	25
Pittsburgh	17	16	25	20
Reading	16	15	16	19
Williamsport	17	15	16	20
York	18	12	16	19
State average	16.7	15.5	18.5	22.6

TABLE 8.—GAMMA EMITTING RADIONUCLIDES IN PENNSYLVANIA MILK, MARCH 1964 [a]

[Concentrations in pc/liter]

Sampling location	Cesium-137	Potassium-40
Altoona	160	1,334
Dauphin	111	1,445
Erie	133	1,582
Kingston	178	1,773
Lancaster	138	1,463
Philadelphia	124	1,501
Pittsburgh	123	1,633
Reading	121	1,542
Williamsport	137	1,728
York	145	1,624
State average	137	1,563

[a] The monthly average I^{131} and Ba^{140}-La^{140} at each station was <10 pc/liter.

5. Radiostrontium in Milk,[3] October–December 1963

Health and Safety Laboratory, U. S. Atomic Energy Commission

The Health and Safety Laboratory began monitoring liquid whole milk in New York City in 1954 for strontium–90 in order to estimate the dietary contribution from the ingestion of radiostrontium in milk. Subsequently, powdered milk monitoring was initiated at Perry, New York, in 1954 and at Mandan, North Dakota in 1955. Liquid whole milk monitoring was started in Honolulu, Hawaii, in August 1959.

The New York City sample is a monthly composite of pasteurized milk purchased daily in quart containers at retail stores. Five large dairies are represented in the sample. The Honolulu samples are monthly composites of quart samples of pasteurized milk collected weekly. Samples from two dairies are analyzed and the results are averaged. The Mandan and Perry samples are monthly composites of powdered milk collected in 5-pound lots from plants in each city. The Mandan sample is powdered buttermilk used in cattle feeds. Because of its protein and fat content, this buttermilk powder is used primarily as a milk replacer or feed supplement for calves. The Perry sample is powdered whole milk used for human consumption. The source of the Honolulu milk is from the island of Oahu where the cows are on pasture throughout the year, and it is of interest to know how closely the strontium levels in milk in this area reflect changes in deposition rates.

The calcium and strontium–90 data are presented in table 9. The fluctuations of strontium–90 with time are shown in figures 7 and 8.

TABLE 9.—STRONTIUM-90 AND CALCIUM IN MILK, OCTOBER–DECEMBER 1963

Sampling station and 1963 period	Calcium concentration	Strontium-90 concentration	Strontium/Calcium ratio
Liquid Milk	(g/liter)	(pc/liter)	(pc/g Ca)
New York City			
Third Quarter			34.5
October	1.07	31.6	29.6
November	1.09	28.2	25.9
December	0.80	16.5	20.7
Honolulu, Hawaii			
Third Quarter			8.0
October	1.06	13.1	12.5
November	1.13	8.3	7.4
December	1.10	8.2	7.4
Powdered Milk	(g/kg)	(pc/kg)	(pc/g Ca)
Perry, New York			
Third Quarter			29.3
October	8.8	264	30.1
November	9.0	199	22.2
December	9.6	212	22.1
Powdered Buttermilk			
Mandan, North Dakota			
Third Quarter			57.8
October	11.2	937	83.7
November	11.2	842	75.6
December	12.2	836	68.6

Comment

A marked increase in the strontium–90 content of milk from the continental U. S. stations was observed beginning in May 1963, due to the heavy spring fallout deposition. It is apparent from figures 7 and 8 that the peak strontium–90 concentrations were reached in the summer.

[3] Data summarized from *Health and Safety Laboratory, AEC, Fallout Program Quarterly Summary Report, HASL–144:* 175–83, Office of Technical Services, Department of Commerce, Washington, D. C. 20230 (April 1, 1964), price $4.00.

The Honolulu milk samples still contain less strontium–90 per liter than those of other sampling stations, although there was also a slight increase in strontium–90 concentrations in the Honolulu samples in May.

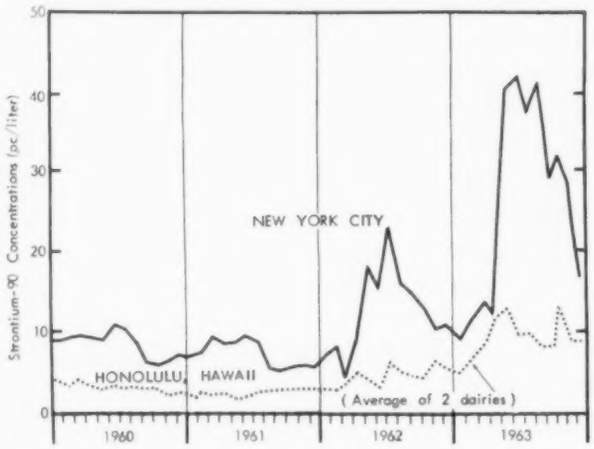


FIGURE 7.—STRONTIUM–90 IN LIQUID MILK

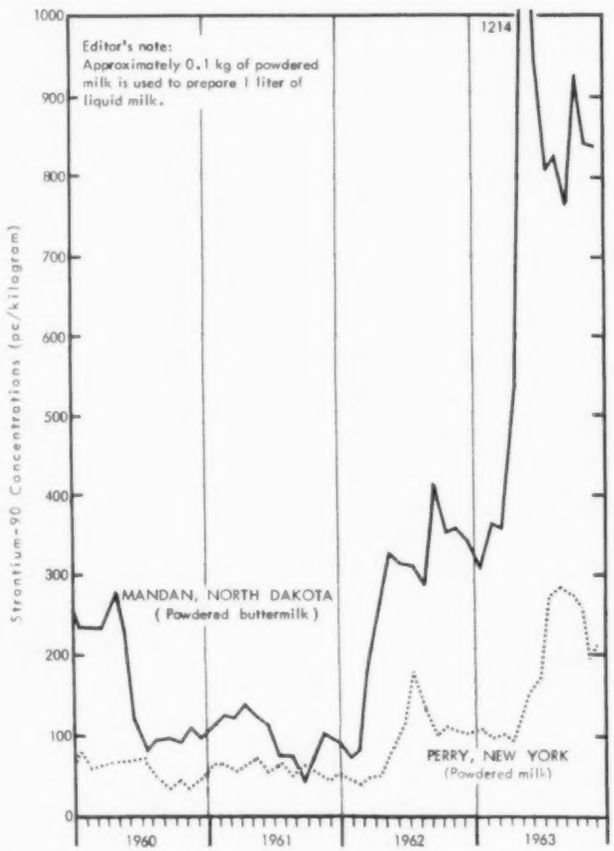


FIGURE 8.—STRONTIUM–90 IN POWDERED MILK

Recent coverage in *Radiological Health Data:*

Period	Issue
March–June 1962	*January 1963*
July–September 1962	*April 1963*
October 1962–March 1963	*October 1963*
April–June 1963	*January 1964*
July–September 1963	*April 1964*

6. Canadian Milk Network,[1] March 1964

Radiation Protection Division
Department of National Health and Welfare,
Ottawa, Canada

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium–90 in November 1955. At first, analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963, liquid whole milk has been analyzed instead. With this change, more representative samples of milk consumed can be obtained, and in addition it is possible to choose milk sampling locations (see figure 9) in the same areas as the air and precipitation stations. At present, the analyses include determinations of iodine–131, strontium–89, cesium–137 and strontium–90 as well as stable potassium and calcium.

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies, combined into weekly composites, and forwarded to the radiochemical laboratory in Ottawa. The contribution of each dairy to the composite sample is directly proportional to its volume of sales. In most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine–131. The results of the spot checks for iodine-131 will not be reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium–90, strontium–89, cesium–137, and stable potassium and calcium.

Analytical Methods

Radiochemical methods are used for the analysis of iodine–131 (*4*). Carrier iodine is added and the milk is then evaporated in the presence of sodium hydroxide and ashed. The iodide ion is oxidized to free iodine and extracted with carbon tetrachloride, back-extracted in sulfite

[1] Data from *Radiation Protection Programs, Vol. 2, No. 4*:25–30, Radiation Protection Division, Canadian Department of National Health and Welfare (April 1964).

solution, and precipitated as silver iodide. The precipitate is counted in a low background beta counter and the iodine–131 determined by comparison with standard preparations.

For the analysis of radiostrontium, carrier strontium is added to a one-liter sample of milk; the milk is then placed in a tray lined with a polyethylene sheet, and evaporated under infra-red lamps. The residue is ashed in a muffle furnace at 450°C, dissolved in dilute nitric acid, and strontium separated by fuming nitric acid precipitation. The combined strontium–89 and strontium–90 are determined by counting in a low background beta counter. Strontium–90 is determined separately by extracting and counting the yttrium–90 daughter nuclide while strontium–89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages. Calcium is determined by flame photometry.

Cesium–137 is determined by gamma spectroscopy using a scintillation crystal and a multi-channel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5 x 4-inch sodium iodide crystal detector. The sample is counted for 100 minutes and the gamma spectrum recorded. Estimates are made of the potassium–40 and cesium–137 content of the milk by comparison of the spectrum with standard preparations. The stable potassium content is estimated from the potassium–40 concentration.

Sources of Error

In the iodide and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radioisotope in the milk because it depends only on the recovery of the carrier. In the determination of cesium–137 this factor is not involved.

The chemical procedures error must be combined with the counting error which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are given in table 10.

TABLE 10.—TOTAL ERROR FOR VARIOUS RADIONUCLIDE CONCENTRATIONS IN MILK [a]

Nuclide	Error for 10 pc/liter	Error for 50 pc/liter	Error for 100 pc/liter
Strontium-89	±25%	±20%	±15%
Strontium-90	±15%	±10%	±10%
Iodine-131	±50%	±20%	±10%
Cesium-137	±60%	±25%	±10%

[a] All errors are 2σ values, representing 95 percent confidence.

Results

Table 11 presents monthly averages of strontium–90, cesium–137, stable calcium, and potas-

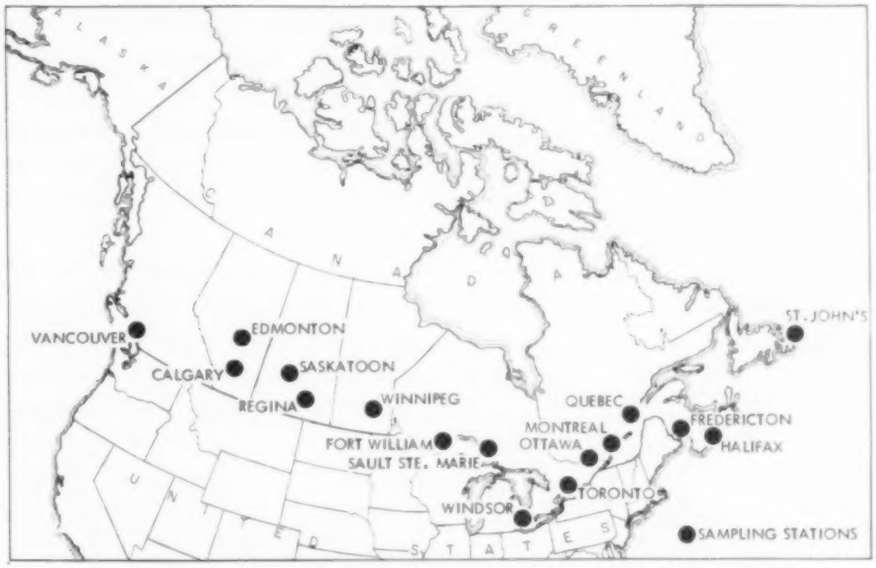


FIGURE 9.—CANADIAN MILK SAMPLING STATIONS

sium in Canadian whole milk. Spot checks for strontium–89 and iodine–131 indicate that all samples had <5 pc/liter. Figure 10 shows the variation of the network average of the radionuclide concentration in Canadian whole milk.

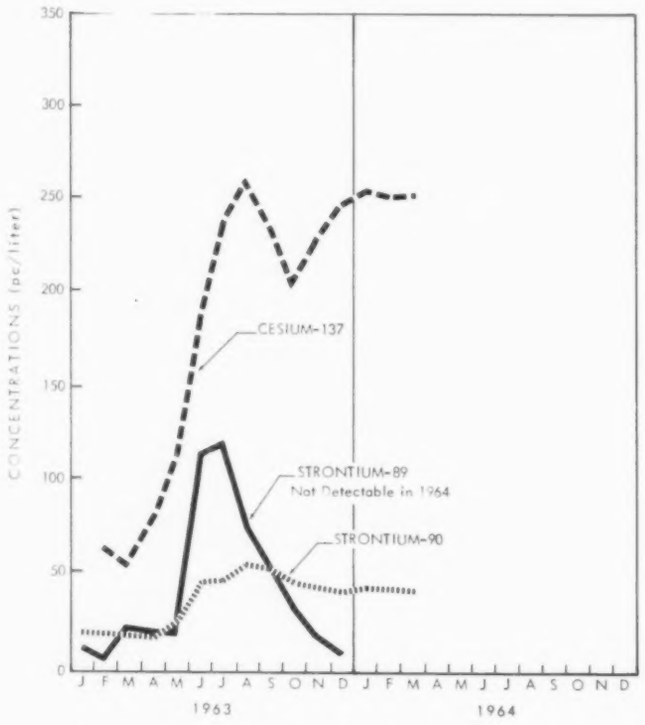


FIGURE 10.—NETWORK AVERAGE STRONTIUM–89, STRONTIUM–90, AND CESIUM–137 CONCENTRATIONS IN CANADIAN WHOLE MILK

TABLE 11.—RADIONUCLIDES IN CANADIAN WHOLE MILK, MARCH 1964

[Radionuclide concentrations in pc/liter]

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90	Cesium-137
Calgary	1.38	1.6	52.4	229
Edmonton	1.30	1.5	36.1	296
Ft. William	1.34	1.6	57.2	293
Fredericton	1.41	1.6	49.9	378
Halifax	1.40	1.6	39.7	291
Montreal	1.32	1.6	40.2	280
Ottawa	1.36	1.7	32.0	226
Quebec	1.30	1.6	47.6	341
Regina	1.29	1.6	46.0	211
St. John's, Nfld	1.32	1.6	41.4	259
Saskatoon	1.35	1.7	50.5	224
Sault Ste. Marie	1.38	1.6	35.9	212
Toronto	1.43	1.5	17.6	149
Vancouver	1.41	1.6	37.5	272
Windsor	1.41	1.6	17.8	110
Winnipeg	1.30	1.6	47.7	249
Average	1.36	1.6	40.6	251

REFERENCES

(*1*) Public Health Service: Summary of Results from the Raw Milk Sampling Program, June 1957–April 1963, *Radiological Health Data, 4:* 511–23 (October 1963).

(*2*) Porter, C., D. Cahill, R. Schneider, P. Robbins, W. Perry, and B. Kahn: Determination of Strontium–90 in Milk by an Ion Exchange Method, *Analytical Chemistry, 33:* 1306–8 (September 1961).

(*3*) Kahn, B., *et al.: Rapid Methods for Estimating Fission Product Concentrations in Milk, Public Health Service Publication No. 999–R–2,* (March 1963). Single copies available on request from Public Inquiries Branch, PHS, U.S. Department of Health, Education, and Welfare, Washington, D.C. 20201.

(*4*) DasGupta, A. K., and H. G. Green: *A Method for the Radiochemical Determination of Iodine–131 in Milk, RPD–23,* Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada (October 1963).

MOVING ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN PASTEURIZED MILK, APRIL 1963—MARCH 1964

Division of Radiological Health, Public Health Service

Radionuclide concentration values reported by the Pasteurized Milk Network (*1*) can be used to estimate the contribution of milk to a population's radiation exposure. This is done by determining both the annual average concentrations of specific radionuclides in milk and the average daily milk consumption of a representative individual in a suitable sample of the population.

The data listed in table 1 are concerned with the first of these requirements, *i.e.*, annual average concentrations of strontium–89, strontium–90, iodine–131 and cesium–137 in one liter of pasteurized milk. Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U.S. population (*2, 3*).

To arrive at a basis of comparison between the daily rates of intake of the radionuclides from the milk component of the diet and the Federal Radiation Council's ranges of transient daily rates of intake (*4*), it is assumed that the average daily milk consumption of an individual in a population group is one liter. The Guides, however, apply to total intake from all sources. The upper limits of Range II correspond to the Radiation Protection Guide (RPG) for iodine–131 and one third of the Radiation Protection Guide for radioactive strontium. The Guides are, for administrative reasons, expressed as a yearly radiation dose, but are based on lifetime exposure (*5*). The FRC emphasizes that the annual acceptable risk or exposure dose is not a dividing line between safety and danger in actual radiation situations (*6*).

Annual averages of radionuclide concentrations in milk sampled by the PHS Pasteurized Milk Network are presented in table 1. The data in table 1 are calculated as follows: Results from all samples collected in each week (Sunday through Saturday) are averaged, and the averages for all weeks terminating in each of twelve consecutive months are averaged to obtain the annual average.[2] To obtain the annual average daily intake (pc/day) of radionuclides from milk, the annual average concentration values (pc/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk (*3, 4*).

Monthly variations of radionuclide concentrations in milk are influenced by a number of combined causes such as weather conditions and dairying practices. The moving yearly average (table 1), obtained by updating the previous twelve-month average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations. This method, therefore, shows trends over a considerable period of time.

REFERENCES

(*1*) Public Health Service: Milk Surveillance—Pasteurized Milk Network, *Radiological Health Data, 5*:57–61 (February 1964).

(*2*) Bureau of the Census, and Public Health Service: National Food Consumption Survey, Fresh Whole Milk Consumption in the United States, July 1962, *Radiological Health Data 4*:15–17 (January 1963).

(*3*) Bureau of the Census and Public Health Service: Consumption of Selected Food Items in U. S. Households, July 1962, *Radiological Health Data, 4*:124–7 (March 1963).

(*4*) Federal Radiation Council: Radiation Protection Guidance for Federal Agencies, *Federal Register:* 9057–8, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 (September 26, 1961).

(*5*) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2,* Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (September 1961). Price 20 cents.

(*6*) Public Health Service: Special Report, *Radiological Health Data, 3*:ii–iii, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 (September 1962).

[2] Beginning with the October 1963 data, iodine–131 values of <10 pc/liter are considered to be zero for averaging purposes; previously 5 pc/liter was used in calculating the average.

TABLE 1.—MOVING ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN MILK

[Concentrations in pc/liter]

Sampling locations		Strontium-89		Strontium-90		Cesium-137	
		March 1963—February 1964 [a]	April 1963—March 1964 [b]	March 1963—February 1964 [a]	April 1963—March 1964 [b]	March 1963—February 1964 [a]	April 1963—March 1964 [b]
Ala:	Montgomery	46	38	22	22	85	89
Alaska:	Palmer	29	28	23	24	132	140
Ariz:	Phoenix	9	8	4	4	22	22
Ark:	Little Rock	91	80	43	44	160	166
Calif:	Sacramento	36	32	11	11	63	66
	San Francisco	62	50	14	14	77	79
Colo:	Denver	24	23	17	18	86	90
Conn:	Hartford	21	21	24	26	161	173
Del:	Wilmington	27	27	25	26	133	141
D. C:	Washington	37	37	20	20	100	105
Fla:	Tampa	24	18	15	15	225	231
Ga:	Atlanta	67	58	31	32	148	156
Hawaii:	Honolulu	28	20	11	11	76	79
Idaho:	Idaho Falls	47	48	27	27	154	167
Ill:	Chicago	18	18	21	21	113	120
Ind:	Indianapolis	27	26	24	24	102	108
Iowa:	Des Moines	54	54	26	28	93	98
Kans:	Wichita	37	37	20	22	74	78
Ky:	Louisville	79	76	33	35	113	121
La:	New Orleans	101	68	44	46	156	158
Maine:	Portland	25	26	32	33	209	220
Md:	Baltimore	45	45	21	22	123	129
Mass:	Boston	30	31	36	36	232	248
Mich:	Detroit	16	16	20	20	114	119
	Grand Rapids	17	17	21	21	120	127
Minn:	Minneapolis	46	47	32	33	153	161
Miss:	Jackson	98	69	37	37	116	119
Mo:	Kansas City	61	60	28	30	86	91
	St. Louis	45	43	23	24	88	93
Mont:	Helena	43	43	28	30	182	195
Nebr:	Omaha	46	45	26	27	97	103
Nev:	Las Vegas	15	15	10	11	72	77
N. H:	Manchester	28	29	34	35	254	268
N. J:	Trenton	21	21	22	22	124	132
N. Mex:	Albuquerque	18	17	10	11	46	49
N. Y:	Buffalo	21	21	23	23	141	149
	New York	29	29	30	31	165	178
	Syracuse	23	24	24	25	138	148
N. C:	Charlotte	61	58	32	33	123	128
N. Dak:	Minot	80	81	53	55	143	150
Ohio:	Cincinnati	33	32	26	27	95	101
	Cleveland	22	23	22	23	110	117
Okla:	Oklahoma City	53	48	24	24	90	93
Ore:	Portland	63	60	31	32	162	171
Pa:	Philadelphia	25	25	23	24	126	134
	Pittsburgh	32	32	29	30	151	160
P. R:	San Juan	45	36	14	14	87	89
R. I:	Providence	25	25	28	29	169	178
S. C:	Charleston	47	38	28	29	128	133
S. Dak:	Rapid City	62	61	40	42	154	164
Tenn:	Chattanooga	91	82	39	40	146	154
	Memphis	73	62	32	33	90	93
Tex:	Austin	22	19	9	10	47	49
	Dallas	51	42	21	21	82	84
Utah:	Salt Lake City	31	31	24	26	162	174
Vt:	Burlington	25	25	29	29	181	193
Va:	Norfolk	40	37	22	22	103	108
Wash:	Seattle	51	50	25	27	150	157
	Spokane	47	47	29	30	141	147
W. Va:	Charleston	62	61	30	31	103	108
Wis:	Milwaukee	17	17	19	20	121	129
Wyo:	Laramie	35	35	22	23	115	119
Network average		42	39	25.2	26.0	124	131

[a] Annual averages were computed on basis of 52 weekly averages.
[b] Annual averages were computed on basis of 53 weekly averages.

RADIONUCLIDES IN INSTITUTIONAL DIET SAMPLES, OCTOBER—DECEMBER 1963

Division of Radiological Health, Public Health Service

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiation surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is administered by the Division of Radiological Health with the assistance of the Division of Environmental Engineering and Food Protection (*1*).

The program is designed to estimate the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program consisted of sampling diets in eight institutions, but it has since been expanded to 21 boarding schools or institutions, geographically distributed as shown in figure 1. Institutions selected range from financially well-to-do boarding schools to orphanages with severe economic limitations. Each institution (sampling point) except the one at Los Angeles is located in a community from which the PHS Pasteurized Milk Network collects samples. The analytical data from this program supplement the findings for the Institutional Diet Sampling Program.

FIGURE 1.—INSTITUTIONAL DIET SAMPLING LOCATIONS

Sampling Procedure

In general, the sampling procedure is the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks) obtained by duplicating the meals of a different individual each day. Each institution supplies one complete 7-day, 21-meal diet sample each month. Each day's sample is kept frozen during the collection period. After collection, the total sample is packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nevada, the Southeastern Radiological Health Laboratory, Montgomery, Alabama, or the Northeastern Radiological Health Laboratory, Winchester, Massachusetts.

Each sample is packaged in three parts: (1) solid food and semisolid foods minus those portions that would not ordinarily be eaten; (2) liquid milk; (3) other beverages such as soft drinks, coffee and tea. A record of the contents of each meal and the approximate amount of each item is made at the institutions and sent with the sample.

Analytical Procedures

Because calcium and phosphorus compounds may have an effect on the uptake of important bone-seeking radionuclides such as strontium–89 and strontium–90 (*2*), they are included in the analytical program. Total weight, stable calcium, and stable potassium determinations are obtained by conventional gravimetric or spectrophotometric methods. Samples usually range from 6 to 16 liters in volume and weigh from 8 to 20 kilograms. Phosphate determinations are made by a colorimetric technique.

The radioanalysis program is designed around three basic procedures: (1) gamma spectroscopy, (2) chemical separation of strontium–89 and strontium–90 with subsequent counting, and (3) radium–226 analysis. In the absence of interferences other than that from naturally-occurring radioactive potassium (K^{40}), minimum detectable concentrations for

the gamma scan expressed as pc/kg are: iodine–131, 10 pc/kg; cesium–137, 5 pc/kg; and barium–140, 10 pc/kg. Approximate minimum detectable concentrations for strontium–89, strontium–90, and radium–226 are: 5, 1 and 1 pc/kg, respectively. Since a constant weight of food is analyzed, the minimum detectable level on a per day basis (pc/day) will be dependent on the food intake.

Data

Table 1 presents the dietary intake data expressed on a per-day basis from October 1963 through December 1963 for the 21 institutions from which samples were received. Also contained in the table is the range of ages of the children from which samples are being obtained. The reported radionuclide concentrations of these samples are extrapolated to the midpoint of the sample collection period.

Certain of the radioanalyses are reported by the laboratories as being "less-than" (<) a specified value. For data averaging, the method employed for presentation in table 1 is that all "less-than" data are assumed to be equal to the full "less-than" values as they appear in the column entitled "monthly maximum averages." The column entitled "monthly minimum averages" reflects the averages in which all "less-than" values are considered to be zero.

The data are presented graphically in figure 2 as a distribution of all sample values observed during the three months versus daily intake. The number of values reported during this quarter in each range is plotted as a frequency-distribution step chart. The number of stations used in constructing these graphs was 21, 21, and 20 for the months of October, November, and December 1963, respectively. Therefore, the total number of samples represented in each chart is 62. Figure 3 shows the overall average daily intake of radionuclides at all institutions since January 1961.

TABLE 1.—INSTITUTIONAL DAILY DIETARY INTAKE

	Month (1963)	Alaska Palmer	California Los Angeles	Colorado Denver	Florida Tampa	Georgia Atlanta	Hawaii Honolulu	Illinois Chicago	Louisiana New Orleans	Massachusetts Boston	Minnesota Minneapolis
Age (years)		6–18	11–18	4–17	6–18	6–18	5–16	6–15	7–18	6–14	[a] <1–16
Total weight (kg/day)	Oct.	1.51	2.58	2.76	2.12	1.60	1.47	[b] 1.21	2.35	1.78	1.52
	Nov.	1.54	1.66	2.12	2.50	1.81	1.81	1.48	2.24	2.07	1.62
	Dec.	1.18	2.02	2.68	2.55	1.70	[c]—	1.94	2.37	1.63	2.68
Calcium (g/day)	Oct.	0.8	1.3	1.6	1.4	0.6	0.6	[b] 0.6	1.9	0.9	0.6
	Nov.	0.8	0.9	1.1	1.6	1.0	1.0	1.1	1.5	1.7	0.9
	Dec.	0.7	1.0	1.0	1.6	1.0	[c]—	1.5	1.5	1.2	1.0
Phosphorus as phosphate (g/day)	Oct.	2.9	5.7	5.4	4.4	3.2	2.5	3.0	6.1	1.9	2.9
	Nov.	3.2	3.8	4.7	5.4	3.6	4.4	2.1	5.6	1.9	2.8
	Dec.	2.5	4.4	5.0	6.2	3.0	[c]—	2.9	4.8	1.4	5.1
Potassium (g/day)	Oct.	3.1	4.8	4.5	2.7	1.8	2.5	[b] 2.2	3.4	2.5	2.6
	Nov.	2.5	2.9	3.1	3.6	2.1	3.2	2.6	3.9	3.2	2.4
	Dec.	2.1	1.7	4.4	3.9	2.1	[c]—	3.4	3.4	2.8	4.2
Radium-226 or total radium [d] (pc/day)	Oct.	4.0	<1.0	<1.0	7.5	3.2	<1.0	1.0	7.7	<1.0	<1.0
	Nov.	<1.0	<1.0	<1.0	<6.1	<3.4	2.0	<1.0	<4.4	<1.0	<1.0
	Dec.	<1.0	<1.0	2.0	5.3	<5.1	[c]—	<1.0	<6.5	<1.0	<1.0
Strontium-89 (pc/day)	Oct.	10	5	15	30	20	5	[b] <5	145	25	20
	Nov.	15	10	10	65	95	10	<10	120	<25	15
	Dec.	5	10	<5	25	15	[c]—	<10	15	<15	<5
Strontium-90 (pc/day)	Oct.	20	11	28	31	25	8	[b] 17	48	28	18
	Nov.	23	11	19	25	30	25	26	52	59	16
	Dec.	12	12	2	46	32	[c]—	41	49	37	3
Cesium-137 (pc/day)	Oct.	160	130	205	370	105	140	[b] 80	220	230	120
	Nov.	140	100	115	420	140	155	155	260	390	140
	Dec.	135	100	120	565	130	[c]—	235	285	280	215
Barium-140 (pc/day)	Oct.	<10	<10	<10	<30	<30	<10	[b] <10	<30	<20	<10
	Nov.	<10	<10	<10	<30	<30	<10	<20	<30	<20	<10
	Dec.	<10	<10	<10	<40	<30	[c]—	<20	<30	<20	<10
Iodine-131 (pc/day)	Oct.	<10	<10	<10	<30	<30	<10	[b] <10	<30	<20	<10
	Nov.	<10	<10	<10	<30	<30	<10	<20	<30	<20	<10
	Dec.	<10	<10	<10	<40	<30	[c]—	<20	<30	<20	<10

[a] Food samples not collected for children too young for solid diet.
[b] Data represent amount in solid food portion of diet only.
[c] A sample was collected but no analysis was performed.
[d] The values for Tampa, Atlanta, New Orleans, Memphis, Austin, and Norfolk are total radium values, not Radium-226.

Discussion of Data

From table 1 it is apparent that the total intake ranged between 1.18 and 2.76 kg/day with an average of about 1.9 kg/day during this quarter. The calcium intake ranged between 0.6 and 2.8 g/day, with twenty-nine percent of the values being less than one g/day. Phosphate intake ranged from 1.4 to 7.1 g/day, with 55 percent of the values ranging from one to 4 g/day. Eighty-nine percent of the samples analyzed for potassium showed that the intake was between 1 and 4 g/day.

All of the 44 samples analyzed for radium–226 ranged between <1 and 5 pc/day with 36 samples having less than 2 pc/day. Eighteen samples were analyzed for total radium (all radium isotopes) and a maximum value of 8.1 pc/day was observed.

Strontium–89 intake ranged between <5 and 145 pc/day. Eighty-two percent of the samples gave values between <5 and 30 pc/day. For purposes of comparison the Federal Radiation Council (FRC) range II for strontium–89 is 200 to 2000 pc/day.

The maximum strontium–90 intake during this quarter was 63 pc/day. Again for comparison, 29 percent of the values were below 20 pc/day. This is similar to last quarter's results. The FRC range II for strontium–90 is 20 to 200 pc/day (*3*).

Although the intake of cesium–137 ranged from 60 to 565 pc/day, the distribution shows a pronounced peak between 120 and 160 pc/day formed by 32 percent of the results. It appears that with respect to cesium–137 intake the situation has been static during the last half of 1963.

Both barium–140 and iodine–131 were below the limits of detectability during this quarter.

(BASED ON A 7-DAY COMPOSITE SAMPLE)

Missouri St. Louis	Montana Helena	Nebraska Omaha	New Mexico Albuquerque	New York New York	Ohio Cleveland	Tennessee Memphis	Texas Austin	Utah Salt Lake City	Virginia Norfolk	Washington Seattle	Monthly minimum average	Monthly maximum average
7–16	6–17	6–18	5–15	8–15	6–15	8–18	6–18	12–18	10–18	6–16		
2.28	1.44	1.55	1.80	2.11	1.97	1.99	2.27	1.62	2.18	1.77	1.90	1.90
2.47	1.75	1.50	1.88	1.80	2.07	2.17	2.30	1.26	1.99	1.82	1.90	1.90
2.52	1.41	1.47	1.94	1.97	1.91	2.01	1.94	1.34	2.12	1.91	1.96	1.96
1.6	0.9	0.8	1.1	[b] 1.6	1.8	1.3	1.5	1.1	1.2	1.1	1.2	1.2
1.5	1.2	0.9	1.7	2.8	1.3	1.6	1.4	0.9	1.2	0.9	1.3	1.3
1.7	0.6	0.9	1.5	1.7	1.2	1.4	1.2	0.9	1.2	1.2	1.2	1.2
5.5	3.0	3.1	3.6	3.2	2.2	3.9	6.8	3.2	4.0	3.5	3.8	3.8
5.6	4.2	3.0	5.9	3.5	2.8	4.7	5.6	2.8	4.3	4.0	4.0	4.0
7.1	2.2	3.7	4.9	3.2	2.8	4.7	3.8	3.0	5.3	4.8	4.0	4.0
4.3	2.3	2.8	3.1	[b] 3.2	3.1	2.5	3.2	2.9	2.9	3.1	3.0	3.0
4.2	2.5	2.3	3.2	2.6	3.3	3.5	3.1	2.2	2.6	2.9	2.9	2.9
4.3	1.6	2.1	3.3	3.6	3.6	2.7	2.2	3.0	2.6	3.0	3.0	3.0
1.0	1.0	<1.0	<1.0	2.0	<1.0	4.6	8.1	<1.0	4.4	<1.0	2.1	2.6
1.0	<1.0	2.0	2.0	2.0	1.0	<4.0	<3.5	<1.0	<3.8	<1.0	<1.0	2.1
<1.0	<1.0	<1.0	1.0	1.0	1.0	2.7	<2.7	<1.0	4.5	5.0	1.1	2.5
25	15	15	<5	<10	<15	30	85	20	25	10	24	25
10	25	10	<5	<10	10	75	85	10	85	20	32	34
<5	10	5	10	<10	<10	<10	<10	15	10	20	7	11
25	22	20	15	30	63	36	22	22	36	37	27	27
37	28	18	17	46	29	34	33	5	31	25	28	28
5	17	25	17	40	30	38	24	21	32	27	26	26
160	160	125	70	160	125	95	115	200	110	175	155	155
170	250	105	75	180	155	165	155	150	125	220	179	179
200	150	105	60	255	195	120	115	235	140	160	190	190
<10	<10	<10	<10	<20	<20	<30	<30	<10	<30	<10	0	17
<10	<10	<10	<10	<20	<20	<30	<30	<10	<30	<10	0	18
<10	<10	<10	<10	<20	<20	<30	<30	<10	<30	<10	0	18
<10	<10	<10	<10	<20	<20	<30	<30	<10	<30	<10	0	17
<10	<10	<10	<10	<20	<20	<30	<30	<10	<30	<10	0	18
<10	<10	<10	<10	<20	<20	<30	<30	<10	<30	<10	0	18

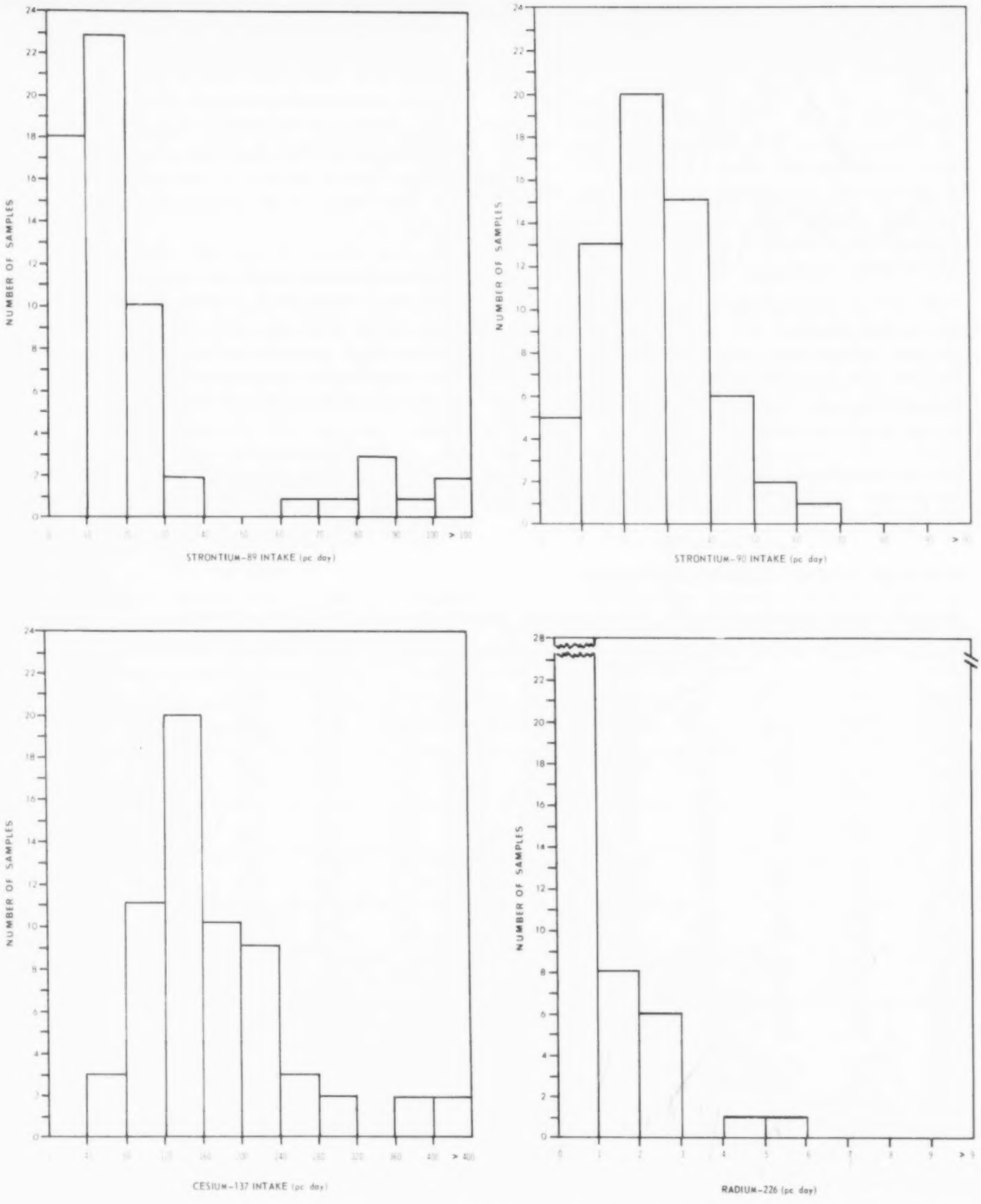
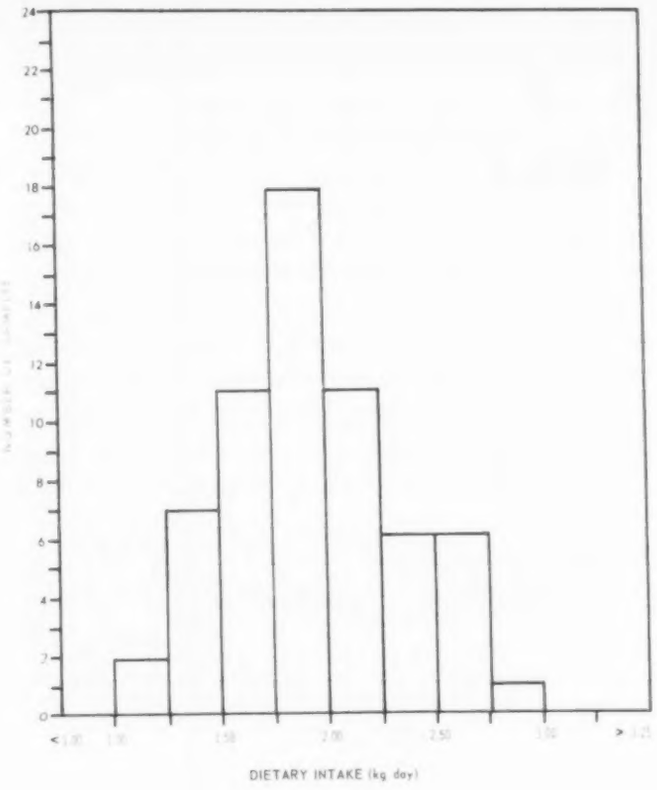
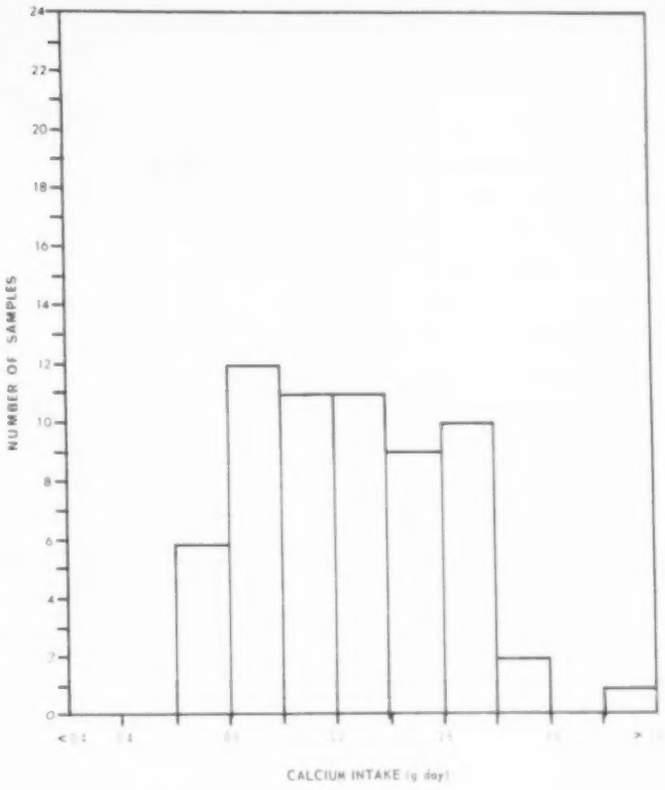
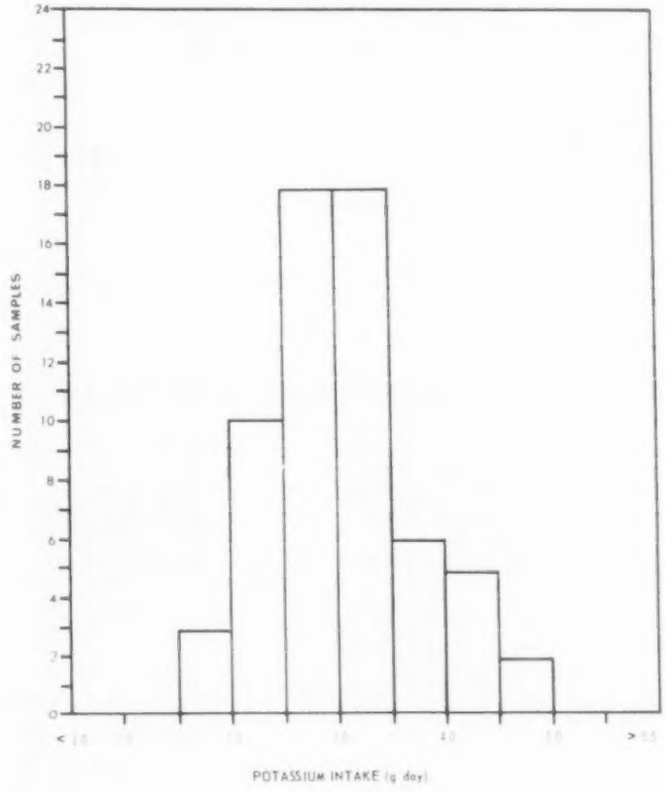
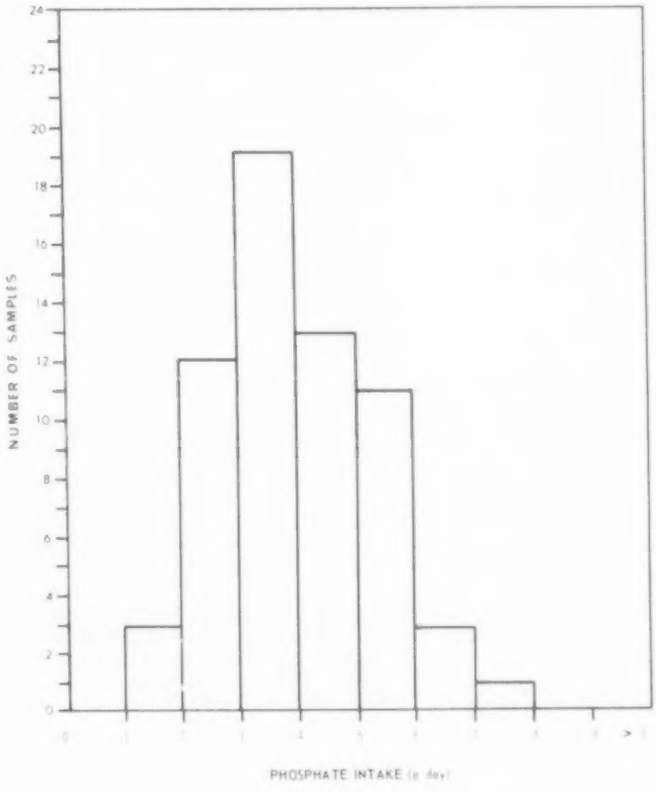


FIGURE 2.—DISTRIBUTION OF THE NUMBER OF SAMPLES VERSUS INTAKE









OF MATERIALS IN INSTITUTIONAL DIETS FOR OCTOBER–DECEMBER 1963

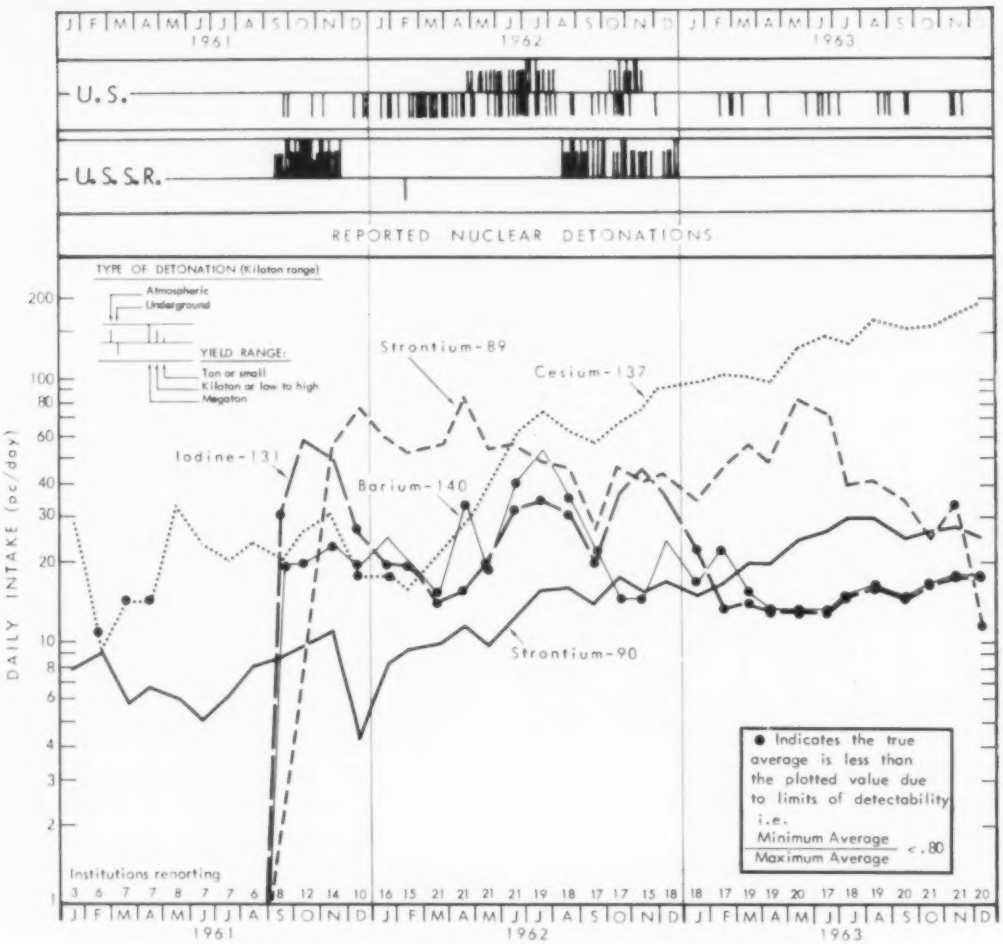


FIGURE 3.—FISSION PRODUCTS IN INSTITUTIONAL DIET SAMPLES—AVERAGE OF INSTITUTIONS

REFERENCES

(*1*) Anderson, E. C., and D. J. Nelson, Jr.: Surveillance for Radiological Contamination in Foods, *American Journal of Public Health, 52:* 1391–400 (September 1962).

(*2*) Chen, P. S., Jr., A. R. Terepka, and H. C. Hodge: The Pharmacology and Toxicology of the Bone Seekers *Annual Review of Pharmacology 1*:369–96 (1961).

(*3*) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2,* Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (September 1961), price 20 cents.

Previous coverage in *Radiological Health Data:*

Period	Issue
July–September 1962	*April 1963*
October–December 1963	*July 1963*
January–March 1963	*September 1963*
April–June 1963	*December 1963*
July–September 1963	*March 1964*

STRONTIUM-90 AND CALCIUM IN INFANT DIETS, 1963[1]

Joseph Rivera[2]

Since the rate of bone formation is high during the first year of life, it is particularly important to know the dietary intake of strontium–90 and calcium during this period so that reasonable estimates can be made of body burdens of strontium–90 in young children. The dietary estimates of strontium–90 intake are complicated since the foods eaten at this age are especially processed and may not have the same strontium–90 concentrations as the same type foods prepared for adult consumption.

For infants who are not breast fed, the diet during the first year of life consists chiefly of specially prepared formula milks, evaporated milk, and, starting at about three months old, specially prepared cereals, vegetables, fruits, and meats (*1*).

For the last quarter of 1963, in addition to sampling the milk components of infant diets at the three cities, non-milk components were also analyzed. The results are presented in table 1 together with estimates of the Sr^{90}/Ca ratio of the total infant diet during the first year of life.

From these data we calculate that about 85 percent of the total Ca intake was from formula and evaporated milks. Assuming this relative fraction to be constant with time, the Sr^{90}/Ca

[1] Originally published in Health and Safety Laboratory, AEC, *Fallout Quarterly Summary Report, HASL–144:* 274–7, Office of Technical Services, U.S. Department of Commerce, Washington, D.C. 20230 (April 1, 1964), price $4.00.

[2] Mr. Rivera is a physicist on the staff of Environmental Studies Division of the Health and Safety Laboratory, U.S. Atomic Energy Commission.

TABLE 1.—STRONTIUM-90 AND CALCIUM IN INFANT DIETS DURING THEIR FIRST YEAR OF LIFE, OCTOBER–DECEMBER 1963 SAMPLING

Location and food category	Average consumption[a] (kg/yr)	Calcium		Strontium-90		Sr^{90}/Ca (pc/g)	
		Concentration (g/kg)	Intake (g/yr)	Concentration (pc/kg)	Intake (pc/yr)		
New York (sampled 11/63)							
Cereals	8	6.57	52.6	23.7	190	3.6	
Vegetables	23	0.35	8.1	17.0	391	48	[b] 10.7
Fruits	23	0.11	2.5	3.7	85	34	
Meats	17	0.15	2.6	2.4	41	16	
Formula milks	37	1.62	59.9	46.7	1,728	29	[c] 33
Evaporated milks	137	2.48	339.8	82.4	11,289	33	
Total diet	245	1.90	466	56.0	13,724		[d] 29
Chicago (sampled 10/63)							
Cereals	8	7.56	60.4	24.1	193	3.2	
Vegetables	23	0.17	3.9	4.7	108	28	[b] 6.1
Fruits	23	0.08	1.8	2.6	60	33	
Meats	17	0.20	3.4	3.9	66	19	
Formula milks	37	1.63	60.3	73.6	2,723	45	[c] 33
Evaporated milks	137	2.54	348.0	73.4	10,558	30	
Total diet	245	1.95	478	56.0	13,708		[d] 29
San Francisco (sampled 12/63)							
Cereals	8	[e] 5.61	44.9	21.8	174	3.9	
Vegetables	23	[f] 0.35	8.1	8.3	191	24	[b] 9.3
Fruits	23	0.04	0.9	1.9	44	49	
Meats	17	[f] 0.17	3.0	7.0	119	40	
Formula milks	37	1.20	44.4	29.6	1,095	25	[c] 12.7
Evaporated milks	137	2.40	328.8	26.7	3,658	11	
Total diet	245	1.96	430	21.6	5,281		[d] 12

[a] Data from HASL-88—see reference 1.
[b] Non-milk component.
[c] Milk component.
[d] Total diet.
[e] August 1961 sampling.
[f] Estimated from New York City and Chicago samples.

TABLE 2.—STRONTIUM-90 CONCENTRATIONS AND INTAKE OF INFANTS FROM MILK DURING 1963

Location and sampling date	Formula milk		Evaporated milk		Total intake from milk (pc/yr)
	Concentration (pc/kg)	Intake (pc/yr)	Concentration (pc/kg)	Intake (pc/yr)	
New York City					
February	[a] 22.7 ±0.9	840	45.9 ±2.3	6288	7128
May	28.2 ±0.9	1043	35.0 ±1.3	4795	5838
August	41.9 ±0.1	1550	40.8 ±1.1	5590	7140
November	46.7 ±0.4	1728	82.4 ±1.8	11289	13017
Average	—	1290	—	6991	8281
Chicago					
January	26.7 ±0.7	988	46.5 ±1.0	6371	7359
April	13.9 ±0.6	514	41.7 ±1.4	5713	6227
June	27.4 ±0.9	1014	52.9 ±1.4	7249	8261
October	73.6 ±1.5	2723	73.4 ±2.3	10558	13281
Average	—	1310	—	7472	8782
San Francisco					
March	32.3 ±1.2	1195	10.1 ±0.6	1384	2579
June	27.6 ±0.7	1021	38.9 ±1.1	5329	6350
September	23.2 ±0.7	858	18.6 ±0.9	2548	3406
December	29.6 ±0.9	1095	26.7 ±1.3	3658	4753
Average	—	1044	—	3230	4274

[a] Error terms are one standard deviation due to counting.

ratio of the total diet (T.D.) can be expressed as:

$$T.D. = 0.85\ M + 0.15\ N.M.$$

where M is the Sr^{90}/Ca ratio of the milk component of the diet and N.M. is the Sr^{90}/Ca ratio of the non-milk component of the diet. Dividing by M we have:

$$T.D./M = 0.85 + 0.15\ N.M./M$$

Using the data in table 1 it may be seen that at the end of 1963 the ratio N.M./M ranged from 0.2 to 0.7 and averaged roughly ¼ for New York and Chicago so that:

$$T.D. = (0.85 + 0.15 \times \tfrac{1}{4})\ M$$

$$T.D. = 0.9\ M$$

Table 2 summarizes the data collected during 1963 concerning strontium–90 in infant diets.

If the annual Sr–90 intakes from milk products listed in table 2 are divided by the average annual Ca intake from milk components of the diet (394 g/yr as calculated from table 1), then M is obtained. Multiplying this M by 0.9 we obtain estimates of the total diet Sr^{90}/Ca ratio. For average New York City, Chicago, and San Francisco infant diets during 1963, these estimates are 19, 20, and 10 pc/g Ca respectively.

If the diet-bone observed ratio for one year old children is 0.3 (*2*) then the expected Sr^{90}/Ca ratio of bones of one year old children who died in the first quarter of 1964 in New York City and Chicago should be between 6 and 7 pc/g Ca while bone specimens from children who lived in San Francisco prior to death can be expected to have Sr^{90}/Ca ratios of about 3 pc/g Ca.

During 1964, it is expected that the ratio N.M./M will become equal to or exceed unity. The reason for this is that cereal products and other non-milk foods produced during periods of relatively heavy fallout in 1963, will then begin to become available in retail markets. However, even if the ratio N.M./M increases tenfold from 0.25 to 2.5 the ratio T.D./M will only change from 0.9 to 1.2 so that the Sr^{90}/Ca ratio of milk products will continue to be a good approximation of the Sr^{90}/Ca ratio of the total diet of infants.

REFERENCES

(*1*) U.S. Atomic Energy Commission: *Health and Safety Laboratory, Fallout Program Quarterly Summary Report, HASL–88:* 230–8, Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (July 1, 1960), price $3.50.

(*2*) U.S. Atomic Energy Commission: *Health and Safety Laboratroy, Fallout Program Quarterly Summary Report, HASL–138:* 235–8, Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (July 1, 1963), price $3.50.

Previous coverage in *RHD:*

Period	Issue
August 1959 and January 1960	*October 1960*
1959–1961	*November 1962*
1959–1962	*August 1963*

Section III—Water

RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, JANUARY 1964

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been under surveillance by the Public Health Service Water Pollution Surveillance System since its initiation in 1957. Beginning with the establishment of 50 sampling points, this System has expanded to 130 stations as of May 1, 1964. These are operated jointly with other Federal, State, and local agencies, and industry. Samples are taken from surface waters of all major U. S. river basins for physical, chemical, biological and radiological analyses. These data can be used for evaluating sources of radioactivity which may affect specific domestic, commercial, and recreational uses of surface water. Further, the System provides background information necessary for recognizing pollution and water quality trends and for determining levels of radioactivity to which the population may be subjected. Data assembled through the System are published in an annual compilation (*1–7*).

FIGURE 1.—TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATER, JANUARY 1964

Sampling Procedures

The participating agencies collect one-liter "grab" samples each week and ship them to the Surveillance System Laboratory in Cincinnati for analysis. Gross alpha and gross beta activity determinations on suspended and dissolved solids and strontium–90 determinations on total solids are performed as frequently as deemed necessary.

Presently, gross alpha and beta determinations are made on monthly composites of the weekly samples received from all stations, except those located downstream from known potential sources of radioactive waste and those from all newly established System stations. Weekly alpha and beta measurements are scheduled routinely during the first year of operation at newly established stations.

Normally, samples are counted within two weeks following collection or within one week after compositing. The decay of activity is followed on each sample for which the first analysis shows unusually high activity. Also, if a recount indicates that the original analysis was questionable, values based on recounting are recorded. All results are reported for the time of counting and are not extrapolated to the time of collection.

Analytical Methods

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*8*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 microns. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is in proper calibration, are used for daily checking of the counters.

Since the fourth quarter of 1958, strontium–90 analyses have been made on three-month composites of aliquots from weekly samples. Beginning in November 1962, two quarterly samples per year have been analyzed for strontium–90 at each sampling point except those stations immediately below nuclear installations. At these stations four determinations per year are performed. The method used for determining strontium–90 is a modification of a procedure described by Harley (*9*). The yttrium–90, together with a yttrium carrier, is precipitated at pH 8.5; the precipitate is washed, redissolved, and reprecipitated as yttrium oxalate and the latter is washed and counted in a low-background, anticoincidence, end-window proportional counter.

Results

Table 1 presents January 1964 results of alpha and beta analyses of U.S. surface waters. The stations on a river are arranged in the table according to their relative location on the river, the first station listed being closest to the headwaters. These data are preliminary. Replicate analyses of some samples as well as some analyses incomplete at the time of this report will be included in the System's Annual Compilation of Data (*7*). The figures for gross alpha and gross beta radioactivity represent either determinations on composite samples or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pc/liter. When all samples have zero pc/liter, the mean is reported as zero; when the calculated mean is between zero and 0.5 the mean is reported as <1 pc/liter. The most recent quarterly strontium–90 results appeared in the January 1964 *RHD* (*10*).

In order to obtain a geographical perspective of the radioactivity in surface water, the numbers alongside the various stations in figure 1 give the January 1964 average total beta activity in suspended-plus-dissolved solids in raw water collected at that station. Results for the years 1957–1962 have been summarized by Weaver *et al.* (*11*).

Discussion

The monthly dissolved beta activity averages exceeded 100 pc/liter only on the Columbia and Clinch Rivers. Of the six stations on the Columbia River, the four downstream from the Hanford Atomic Products Operations facility had averages of between 79 and 763 pc/liter. It can be observed that the concentration diminishes with distance downstream from the facility.

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, JANUARY 1964

[Average concentrations in pc/liter]

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River:						
Pittsbugh, Pa	6	9	15	0	0	0
Animas River:						
Cedar Hill, N. Mex	2	14	16	0	2	2
Apalachicola River:						
Chattahoochee, Fla	6	9	15	1	0	1
Arkansas River:						
Coolidge, Kansas	14	73	87	2	38	40
Ponca City, Okla	6	10	16	0	2	2
Fort Smith, Ark	6	23	29	0	0	0
Little Rock, Ark	9	20	29	1	1	2
Pendleton Ferry, Ark	11	23	34	1	0	1
Bear River:						
Preston, Idaho	1	19	20	0	0	0
Big Horn River:						
Hardin, Mont	4	31	35	0	7	7
Big Sioux River:						
Sioux Falls, S. Dak	0	22	22	0	0	0
Chattahoochee River:						
Atlanta, Ga	4	6	10	0	0	0
Columbus, Ga	13	8	21	1	0	1
Lanett, Ala	18	8	26	4	0	4
Chena Slough:						
Fairbanks, Alaska	1	3	4	0	0	0
Clearwater River:						
Lewiston, Idaho	4	7	11	0	0	0
Clinch River:						
Clinton, Tenn	3	14	17	0	<1	<1
Kingston, Tenn	15	311	326	0	<1	<1
Colorado River:						
Loma, Colo	9	22	31	1	9	10
Page, Ariz	1	37	38	1	6	7
Boulder City, Nev	4	13	17	0	3	3
Parker Dam, Calif-Ariz	2	16	18	0	6	6
Yuma, Ariz	0	48	48	0	2	2
Columbia River:						
Northport, Wash	2	10	12	0	1	1
Wenatchee, Wash	0	11	11	0	1	1
Pasco, Wash	73	763	836	0	<1	<1
McNary Dam, Ore	27	457	484	0	2	2
Bonneville, Ore	28	337	365	0	<1	<1
Clatskanie, Ore	21	79	100	0	0	0
Connecticut River:						
Wilder, Vt	5	12	17	0	0	0
Northfield, Mass	5	10	15	0	0	0
Enfield Dam, Conn	5	16	21	0	0	0
Cuyahoga River:						
Cleveland, Ohio	4	28	32	<1	0	<1
Delaware River:						
Martins Creek, Pa	5	12	17	0	0	0
Trenton, N. J	11	8	19	0	0	0
Philadelphia, Pa	20	13	33	0	0	0
Escambia River:						
Century, Fla	7	7	14	1	0	1
Great Lakes:						
Duluth, Minn	1	8	9	0	0	0
Sault Ste. Marie, Mich	1	4	5	0	0	0
Milwaukee, Wisc	5	6	11	0	0	0
Gary, Ind	4	6	10	0	0	0
Port Huron, Mich	2	8	10	0	0	0
Detroit, Mich	1	7	8	0	0	0
Buffalo, New York	3	12	15	0	1	1
Green River:						
Dutch John, Utah	2	32	34	0	2	2
Hudson River:						
Poughkeepsie, N. Y	6	15	21	0	0	0
Illinois River:						
Peoria, Ill	7	17	24	2	2	4
Grafton, Ill	84	40	124	2	0	2
Kanawha River: Winfield Dam, W. Va	6	9	15	0	0	0
Kansas River:						
De Soto, Kansas	3	29	32	0	1	1
Klamath River:						
Keno, Oreg	6	13	19	0	0	0
Little Miami River:						
Cincinnati, Ohio	28	38	66	1	1	2
Maumee River:						
Toledo, Ohio	5	27	32	0	0	0
Mississippi River:						
St. Paul, Minn	1	21	22	0	0	0
Dubuque, Iowa	2	20	22	0	3	3
Burlington, Iowa	1	14	15	0	1	1
E. St. Louis, Ill	5	22	27	0	0	0
Cape Girardeau, Mo	11	16	27	1	2	3
W. Memphis, Ark	12	17	29	1	1	2
Vicksburg, Miss	30	18	48	3	1	4
Delta, La	10	16	26	1	1	2
New Orleans, La	8	20	28	1	1	2
Missouri River:						
Williston, N. Dak	5	19	24	1	6	7
Bismarck, N. Dak	1	19	20	0	2	2
Yankton, S. Dak	10	24	34	2	2	4
Omaha, Nebr	4	20	24	0	2	2
St. Joseph, Mo	2	20	22	0	4	4
Kansas City, Kans	5	24	29	1	3	4
Missouri City, Mo	5	25	30	0	0	0
St. Louis, Mo	11	20	31	1	3	4
Monongahela River:						
Pittsburgh, Pa	2	5	7	0	0	0
North Platte River:						
Henry, Nebr	8	44	52	1	34	35
Ohio River:						
Addison, Ohio	14	11	25	1	0	1
Huntington, W. Va	8	9	17	0	0	0
Cincinnati, Ohio	19	10	29	2	0	2
Louisville, Ky	8	11	19	0	0	0
Evansville, Ind	8	11	19	0	0	0
Cairo, Ill	31	13	44	8	0	8
Toronto, Ohio	13	10	23	1	0	1
Ouachita River:						
Bastrop, La	8	26	34	0	2	2
Pend Oreille River:						
Albeni Falls Dam, Idaho	2	5	7	0	0	0
Platte River:						
Plattsmouth, Nebr	4	25	29	0	6	6
Potomac River:						
Williamsport, Md	14	13	27	0	0	0
Great Falls, Md	21	9	30	2	0	2
Washington, D.C	17	10	27	2	0	2
Rainy River:						
Baudette, Minn	4	45	49	0	0	0
International Falls, Minn	3	31	34	0	0	0
Red River, North:						
Grand Forks, N. Dak	2	41	43	0	1	1
Red River, South:						
Denison, Tex	1	30	31	0	0	0
Index, Ark	3	24	27	1	0	1
Bossier City, La	5	28	33	0	0	0
Alexandria, La	26	29	55	5	1	6
Rio Grande River:						
Alamosa, Colo	2	7	9	1	1	2
El Paso, Tex	7	27	34	1	4	5
Laredo, Tex	5	14	19	1	3	4
Brownsville, Tex	4	20	24	0	4	4
Roanoke River:						
John H. Kerr Resr/ Dam, Va	4	10	14	0	0	0
Sabine River:						
Ruliff, Tex	21	24	45	1	0	1
Sacramento River:						
Courtland, Calif	4	7	11	0	1	1
St. Lawrence River:						
Massena, N. Y	1	10	11	0	0	0
San Joaquin River:						
Vernalis, Calif	4	13	17	0	3	3
San Juan River:						
Shiprock, N. Mex	8	27	35	1	11	12
Savannah River:						
North Augusta, S. C	7	11	18	1	0	1
Port Wentworth, Ga	7	23	30	1	0	<1
Schuylkill River:						
Philadelphia, Pa	32	9	41	1	0	1
Shenandoah River:						
Berryville, Va	9	7	16	0	0	0
Ship Creek:						
Anchorage, Alaska	1	3	4	0	0	0
Snake River:						
Ice Harbor Dam, Wash	1	12	13	0	3	3
Wawawai, Wash	20	11	31	3	3	6
Payette, Idaho	10	17	27	0	5	5
South Platte River:						
Julesburg, Colo	24	62	86	3	39	42
Spokane River:						
Post Falls, Idaho	3	8	11	0	0	0
Susquehanna River:						
Sayre, Pa	5	6	11	1	0	1
Conowingo, Md	6	9	15	1	0	1
Tennessee River:						
Lenoir City, Tenn	6	10	16	0	0	0
Chattanooga, Tenn	5	20	25	<1	0	<1
Bridgeport, Ala	5	12	17	0	0	0
Pickwick Landing, Tenn	4	14	18	0	0	0
Tombigbee River:						
Columbus, Miss	25	17	42	2	0	2
Truckee River:						
Farad, Calif	3	6	9	0	0	0
Verdigris River:						
Nowata, Okla	4	31	35	1	1	2
Wabash River:						
New Harmony, Ind	9	16	25	0	0	0
Willamette River:						
Portland, Oreg	17	9	26	1	0	1
Yakima River:						
Richland, Wash	1	6	7	0	2	2
Yellowstone River:						
Sidney, Mont	3	22	25	0	3	3
Maximum	73	763	836	5	39	42
Minimum	0	3	4	0	0	0

The dissolved alpha activity, which is associated with the dissolving of natural surface minerals by water, range in monthly averages to 39 pc/liter. Of all stations, three on different rivers had monthly average dissolved alpha activity greater than 10 pc/liter.

While there are no generally applicable standards for surface water, the radioactivity associated with dissolved solids provides a rough indication of the levels which could occur in treated water, since nearly all suspended matter is removed by the treatment process (*12*). The Public Health Service Drinking Water Standards state that in the absence of strontium–90 and alpha emitters,[1] a water supply is acceptable when the gross beta concentration does not exceed 1000 pc/liter (*13*).

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[1] Absence is taken here to mean a negligibly small fraction of the specific limits of 3 pc/liter and 10 pc/liter for unidentified alpha emitters and strontium–90, respectively.

[2] Single free copies of this publication may be obtained from: Public Inquiries Branch, Public Health Service, U.S. Department of Health, Education, and Welfare, Washington, D.C. 20201.

Section IV—Other Data

MEDICAL X-RAY UNITS IN THE CITY OF BALTIMORE: FINDINGS OF THE 1963 PILOT SURVEY

Perry F. Prather, Robert E. Farber and Howard E. Chaney[1]

During the summer months of 1963, a survey was made of the X-ray units and installations in the offices of a selected group of physicians in the City of Baltimore, Maryland. Those selected were members of the Baltimore City Medical Society practicing in the center of the City.

The Survey was conducted as a joint, cooperative venture by the Maryland State Department of Health, the Baltimore City Health Department and the Public Health Service.

The Commissioner of Health of the City of Baltimore met with the Baltimore City Medical Society and explained the purpose of the survey, emphasizing that participation would be voluntary and that the individual findings would be reported to the participants. It was indicated that the data would be held in confidence and used only in a statistical summary in such a manner as to be individually unidentifiable. The approval and support of the Baltimore City Medical Society was given to the survey.

Following these initial steps, the Commissioner of Health of the City of Baltimore prepared and distributed a letter explaining the survey in detail to the constituent members of the Medical Society.

The principal purpose of the survey was to estimate the degree to which existing X-ray units employed by this segment of the medical profession met minimum standards established by:

1. The National Committee on Radiation Protection and Measurements as published in "Handbook 76" of the National Bureau of Standards (*1*).
2. "Suggested State Regulations for Control of Radiation" prepared by the Council of State Governments in cooperation with the United States Atomic Energy Commission and the Public Health Service (*2*).

(Subsequent to this undertaking, the Maryland State Board of Health and Mental Hygiene adopted regulations on September 27, 1963, to become effective January 1, 1964, according to the above standards.)

Additional objectives of the survey were to:

1. Obtain a basis for extending the estimate of the condition of the medical X-ray units in use in the City to those in the State.
2. Provide field experience in survey techniques for City Health Department personnel.
3. Develop a field survey form and report for machine owners.

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Procedure

Two teams, each consisting of a representative of each participating agency mentioned above, were formed to conduct the field phase of the survey from July 1, 1963 to September 6, 1963.

During the period June 19, 1963 to July 1, 1963, the survey instruments and the techniques to be utilized were demonstrated by members of the State Health Department. Several surveys were made of X-ray units and their installations under the jurisdiction of the health departments. These first surveys were helpful in developing two smoothly functioning survey teams.

Starting with the core of metropolitan Baltimore, the teams surveyed physicians' offices within progressively larger circular areas. Prior to visiting the physicians' offices, Baltimore City Health Department personnel telephoned the offices to verify the possession of an X-ray unit and to arrange a mutually convenient date for the survey.

Approximately one day each week the group assembled to discuss the survey results, note the deficiencies, and prepare the reports to be forwarded to each X-ray machine owner participating in the project.

Survey Findings

The survey data have been summarized and are presented in the following series of tables and commentary.

It will be noted that combination radiographic-fluoroscopic units have been counted as two units. This was felt to be justifiable inasmuch as additional survey procedures, unique for each type unit, were necessary and constituted, at least in part, a separate study.

Efforts were made to visit as many units in as many installations (locations) as time would permit; hospital radiology departments were not included because they were felt to be in close agreement with existing standards (*1*). The miscellaneous group includes those types of practice for which an insignificant number of units were surveyed, making a separate notation unwarranted.

Any limitations of the data would stem primarily from the fact that medical X-ray machines used in general practice were concentrated upon, and machines in other types of practice were surveyed only as they occurred in the course of the study. Additional bias might be introduced by the fact that the X-ray machines surveyed in the center of the City might be significantly different from those found in the rest of the City or in the State.

TABLE 1.—NUMBER OF X-RAY UNITS SURVEYED

Type of Unit	Number
Radiographic [1]	108
Fluoroscopic [1]	74
Therapeutic	18
Chiropractic	2
Total	202

[1] Combination units counted in both groups.

TABLE 2.—X-RAY UNITS—BY TYPE OF MEDICAL PRACTICE

Types of practice	Total number
General practice	28
Internal medicine	32
Orthopedics	17
Radiology	15
Urology	9
Miscellaneous	28
Total	129

Radiographic X-ray Units

Table 3 presents the deficiencies noted during the survey. The survey revealed that 75.9 percent of the diagnostic X-ray units were found to be deficient in one or more aspects. Conversely, 24.1 percent were reported to have no deficiencies.

TABLE 3.—DEFICIENCIES NOTED FOR DIAGNOSTIC RADIOGRAPHIC UNITS

Deficiency	Number	Percent of units surveyed
None	26	24.1
Useful X-ray beam not confined to area of clinical interest	63	58.3
No beam centering device	58	51.9
Total filtration in primary X-ray beam less than 2.5 mm. aluminum equivalent	57	51.8
No cones or diaphragms	28	27.9
Additional primary shielding required	22	20.4
No protective position, such as shield or booth for operator	21	19.4
Operator dose-rate in excess of 1 roentgen per hour	8	7.4
Protective aprons and gloves not available or not used	3	2.8
Operation possible outside shielded area	2	1.9
No device to terminate exposure after pre-set time	1	0.9
No audible communication between patient and operator	1	0.9
Faulty electrical system	1	0.9

In 58.3 percent of the machines, the primary X-ray beam exceeded the area of clinical interest and extended beyond the film. These X-rays do not contribute to the production of a radiograph and result in unnecessary exposure of the patient. Proper cones or a variable diaphragm collimator properly used would reduce or eliminate this unnecessary exposure. Three units were found equipped with variable diaphragm collimators, but improper use negated their value.

Insufficient filtration was found in 51.8 percent of the units checked. Aluminum filters placed in the primary X-ray beam reduce the quantity of soft, low energy X-rays in the beam. The low energy X-rays, not able to penetrate to the film, serve only to expose the patient and contribute nothing to the radiograph.

In approximately 20 percent of the installations surveyed, there was insufficient shielding to protect persons outside of the X-ray room from the primary X-ray beam. In some instances, a simple rearrangement of equipment would suffice; in most others, the proper use of cones or collimators would reduce the area requiring primary shielding. The lack of a control booth, shield, protective apron, the physical arrangement of some installations, or the techniques employed placed the physician (or technician) in a location of high exposure. Although the work load in most cases was low enough so that the maximum permissible exposure was not exceeded, the dose to which these persons were exposed could easily be, and should be, further reduced.

Reportable deficiencies were found in 91.9 percent of the fluoroscopic units surveyed.

The recommendation of the National Committe on Radiation Protection (*1*) is that the X-ray tube target should be 18 inches from the table top or panel and shall not be less than 12 inches; although this recommendation has been in effect for two revisions of the Committee Report, 4.1 percent of the installations were found with this distance less than 12 inches.

Fluoroscopic Units

Table 4 presents the deficiencies noted in the fluoroscopic units surveyed.

The amount of aluminum equivalent filtration was found to be less than the recommended (*1*) 2.5 millimeters in 62.6 percent of the units examined.

TABLE 4.—DEFICIENCIES NOTED FOR FLUOROSCOPIC UNITS

Deficiency	Number	Percent of units surveyed
None	6	8.1
Diaphragm system permits X-ray beam to exceed area of viewing screen	58	78.4
No manually reset, cumulative timer to indicate predetermined time or dose	57	77.0
Total filtration in primary X-ray beam less than 2.5 mm. aluminum equivalent	47	62.6
Dose rate at panel/table top more than 10 roentgens per minute	29	39.7
Viewing screen can be turned out of X-ray beam	16	21.6
Excessive transmission of X-ray beam through viewing screen	13	17.5
Lead protective gloves and aprons not available or not used	5	6.8
Target-to-panel/table top distance less than 12 inches	3	4.1
Defective foot switch	1	1.4

In 78.4 percent of the units, the diaphragm system was found to be improperly adjusted. In these units, when the viewing screen was placed at 15 inches from the panel/table top, the diaphragm system, when fully open, would permit the primary X-ray beam to extend beyond one or more edges of the screen. Thus, the fluoroscopist could be exposed to the primary beam attenuated only by the patient.

In nearly 40 percent of the units surveyed, the dose-rate measured at the panel/table top exceeded the 10 roentgen per minute maximum permissible dose rate for routine fluoroscopy (*1*). Table 5 presents the distribution of the dose-rates found during the survey.

TABLE 5.—OUTPUT AT PANEL/TABLE TOP OF FLUOROSCOPIC UNITS

Output (roentgens/minute)	Percent of units	Cumulative percent
<5	30.9	30.9
5–10	29.4	60.3
10–15	22.1	82.4
15–20	10.3	92.7
20–25	1.4	94.1
25–30	1.4	95.5
>30	4.5	100.0

The viewing screen in 17.5 percent of the units provided inadequate attenuation; *i.e.*, the exposure dose-rate was in excess of 50 milliroentgens per hour.

To restrict the dose a patient receives, a manually reset cumulative timer is recommended as a necessary adjunct; 77 percent of the units were not so equipped.

Dark adaptation was not practiced by 10 percent of those physicians using fluoroscopes. The eye is capable of discerning fainter images if 10 minutes or more are allowed for dark adaptation. This procedure makes it possible to reduce the radiation needed to produce an

acceptable image, thereby reducing the patient dose.

Therapeutic Units

Too few therapeutic units were surveyed to generalize the conditions which might be expected to be encountered over a larger geographical area. It should be noted, however, that although the Grenz ray[1] does not usually require additional structural shielding, the damage to tissue is similar to other X-ray damage but limited to the superficial layers. Eyes, thyroid, and testes are certainly to be considered superficially located; hence, would be susceptible to damage from Grenz rays.

Miscellaneous

During the survey, a number of other items were noted and are presented without comment below for information.

[1] Grenz rays are X-rays produced at voltages of 5 to 20 kv.

Summary and Comments

The special survey of 202 Baltimore physician-office X-ray units located in 129 installations disclosed that more than 75 percent of the units were deficient in one or more items considered to meet minimum standards.

Reception by the majority of the participating physicians was quite favorable; comments were volunteered by many relative to the need for such a survey. It was evident from many questions and remarks that while the radiograph serves as a valuable diagnostic aid, the physical attributes and the subtle hazards are often not familiar to many physicians.

Unsolicited letters and telephone calls from participating physicians and telephone calls from the X-ray service companies are indicative of efforts being expended to make the recommended corrections.

TABLE 6.—PERSONNEL MONITORING USED

Use	Number	Type	Number	Exposure (mr/wk)	Number
Never	90	Film badge	39	Less than 25	39
Present	24	Pocket dosimeter	1	25–100	1
Discontinued	16			More than 100	0

TABLE 7.—TYPES OF UNITS SURVEYED, EXCLUSIVE OF THERAPEUTIC UNITS

Types	Number
Portable	5
Fixed-one tube	40
Tilting table-one tube	28
Tilting table-two tubes	22
Upright fluoroscope	15

TABLE 8.—VOLTAGE INDICATOR UNITS

Units	Number
Kilovolts	95
Primary volts	2
Arbitrary units	10

TABLE 9.—TYPE OF RADIATION WARNING SIGNAL

Type of warning signal	Number
None	61
Control panel light	39
Outside room	5

TABLE 10—TIMING DEVICES USED

Type	Number
None	1
Mechanical	33
Electrical	76

Acknowledgements

The physical surveys were made by Daniel Ready, Public Health Radiation Specialist, Robert E. Corcoran, Public Health Radiation Specialist, and Joe K. Donaldson, Division of Radiological Health, Public Health Service, assigned to the State of Maryland, for the Maryland State Department of Health; by David T. Lewis, Chief of Industrial Hygiene Investigations, Winston Miller, Principal Sanitarian, and Ralph Pfannenstiel, Sanitarian, for the Baltimore City Health Department; and Carl R. Pearson and Michael R. Roberts, then on duty with the Public Health Service.

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ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity data for 23 AEC contractor installations have appeared periodically in *RHD* since November 1960. Following are reports for Oak Ridge Area, Paducah Plant, and Portsmouth Area Gaseous Diffusion Plant. These three installations are grouped together because each operates a gaseous diffusion plant; therefore they have similar systems of environmental monitoring.

Releases of radioactive materials from these plants for the periods covered in the reports below may be compared with standards set forth in the Federal Register, Title 10, Part 20. The appropriate concentration standards are given in table 1.

TABLE 1.—CONCENTRATION STANDARDS [a] PERTAINING TO ENVIRONMENTAL MONITORING AT OAK RIDGE AREA, PADUCAH PLANT, AND PORTSMOUTH PLANT

Line No.	Radionuclide or mixture of unknown nuclides	Air (pc/m³)	Water (pc/liter)
1	If α emitters and Sr^{90}, I^{129}, Pb^{210}, Ac^{227}, Ra^{228}, Pa^{230}, Pu^{241}, Bk^{249} are not present [b]	100	—
2	Cerium-144	200	10,000
3	Cesium-137	500	20,000
4	Cobalt-60	300	30,000
5	Ruthenium-103-106	200	10,000
6	Strontium-90	10	100
7	Thorium-protactinium-234	1000	20,000
8	Uranium-natural	2	20,000
9	Zirconium-niobium-95	1000	60,000

[a] The concentration standards given here were taken from the Atomic Energy Commission's regulation 10CFR, Part 20 (Federal Register, November 17, 1960).

[b] "Not present" implies that the concentration of the nuclide is small compared with its appropriate MPC. According to Federal Register, Title 10, Part 20, August 9, 1961, a group of nuclides may be considered not present if the ratio of each nuclide to its appropriate MPC is equal to or less than $\frac{1}{10}$ and if the sum of these ratios for the group in question is equal to or less than $\frac{1}{4}$.

1. Oak Ridge Area, 1963

Union Carbide Nuclear Company
Oak Ridge, Tennessee

Oak Ridge Area is a complex made up of many installations, including K–25, X–10, and Y–12 areas, the Oak Ridge National Laboratory (ORNL), and the Oak Ridge Gaseous Diffusion Plant (ORGDP).

Radioactive waste materials arising from the operation of atomic energy installations in Oak Ridge Area are collected, treated, and disposed of according to their physical states. Solid wastes are buried in a Conasauga shale formation which has a marked ion exchange activity that enables it to fix radioactive materials. Liquid wastes which contain long-lived fission products are confined in storage tanks or are released to trenches and pits located in the Conasauga shale formation. Low level liquid wastes are discharged, after preliminary treatment, to the surface streams. Air that may become contaminated by radioactive materials is exhausted to the atmosphere from several tall stacks after treatment by means of filters, scrubbers, and/or precipitators.

Air Monitoring

Atmospheric contamination by long-lived fission products and fallout occurring in the general environment of East Tennessee are monitored by two systems of monitoring stations. One system consists of seven stations which encircle the plant areas (figure 1) and provide data for evaluating the impact of all Oak Ridge operations on the immediate environment. A second system consists of seven stations encircling the Oak Ridge Area at distances of from 12 to 75 miles (figure 2). This system provides data to aid in evaluating local conditions and to assist in determining the spread or dispersal of contamination should a major incident occur. Sampling is carried out by passing air continuously through a filter paper. Average concentrations are presented in table 2.

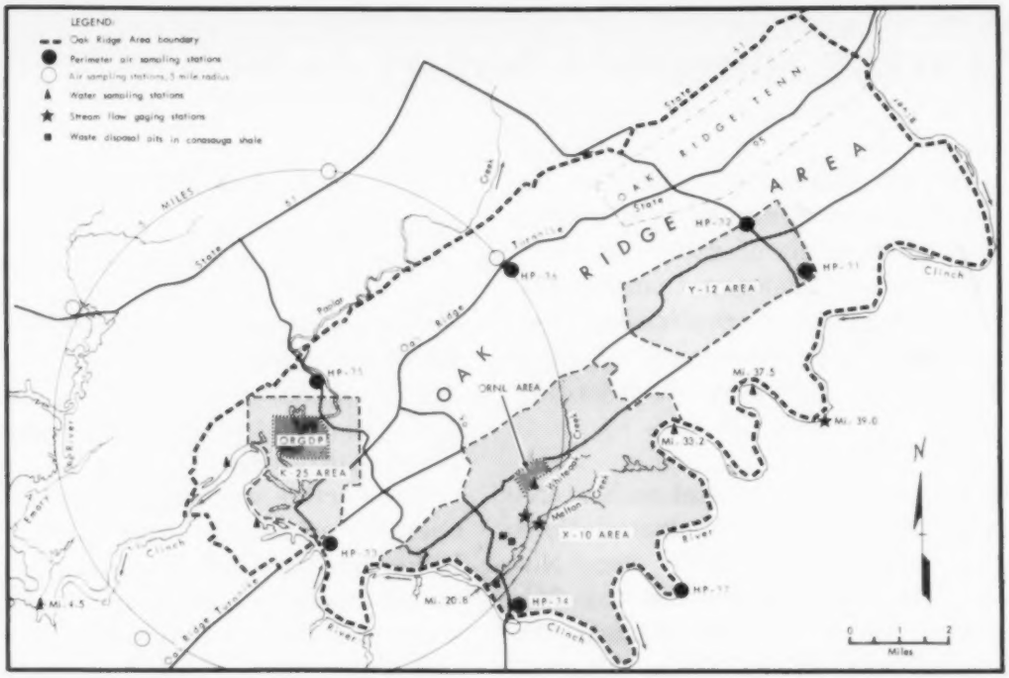

FIGURE 1.—OAK RIDGE AREA ENVIRONMENTAL SAMPLING LOCATIONS

TABLE 2.—LONG-LIVED GROSS BETA CONCENTRATIONS [1] IN AIR OAK RIDGE AREA, 1963

[Average concentrations in pc/m³]

Perimeter stations: (see figure 1)	First half 1963	Second half 1963	Remote stations: (see figure 2)	First half 1963	Second half 1963
HP-31	5.8	2.2	HP-51	5.7	2.3
HP-32	6.1	2.3	HP-52	6.6	2.7
HP-33	5.6	1.6	HP-53	6.5	2.4
HP-34	5.7	1.8	HP-54	6.7	2.7
HP-35	6.7	2.2	HP-55	6.1	2.3
HP-36	6.4	2.2	HP-56	6.3	2.4
HP-37	5.6	2.0	HP-57	5.9	2.2
Average	6.0	2.0	Average	6.3	2.4

[1] For MPC, see table 1, line 1.

Atmospheric contamination by uranium is determined by gross alpha measurements of continuous 8-hour air samples taken at five locations on a five-mile radius from the ORGDP (figure 1). The data are summarized in table 3.

Water Monitoring

Large volume, low level liquid wastes originating at ORNL are discharged, after some preliminary treatment, into the Tennessee River System by way of White Oak Creek and

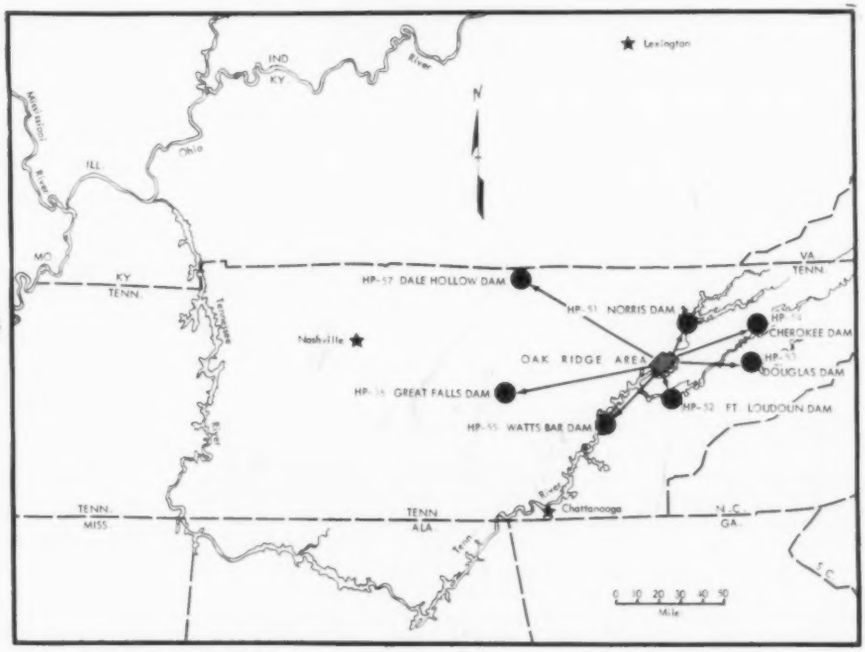

FIGURE 2.—REMOTE AIR MONITORING STATIONS, OAK RIDGE AREA

TABLE 3.—LONG-LIVED ALPHA ACTIVITY IN AIR [1] FIVE MILES FROM ORGDP

[Average concentrations in pc/m³]

Direction from plant	First half 1963	Second half 1963
North	0.17	0.25
East	0.17	0.50
South	0.23	—
West	0.35	0.25
Average	0.22	0.40

[1] Interpreted as uranium (natural).

to obtain dilution factors for calculating the probable concentrations of wastes in the river.

Samples are analyzed for the long-lived beta emitters, for uranium, and for the transuranic alpha emitters.

Analyses are made of the effluent for the long-lived radionuclides only, since cooling time and hold-up time in the waste effluent system is such that no short-lived radionuclides are present. The averages are given in tables 4 and 5.

TABLE 4.—CONCENTRATIONS OF MAJOR RADIONUCLIDES IN THE CLINCH RIVER

[Average concentrations in pc/liter]

Radionuclide	First half 1963			Second half 1963		
	Location on Clinch River [a]			Location on Clinch River [a]		
	Mi. 41.5 (Upstream)	Mi. 20.8 [b] (Outfall)	Mi. 4.5 (Downstream)	Mi. 41.5 (Upstream)	Mi. 20.8 [b] (Outfall)	Mi. 4.5 (Downstream)
Sr^{90}	1.0	1.4	2.1	1.5	1.4	3.6
Ce^{144}	2.7	0.2	3.8	1.3	0.1	1.6
Cs^{137}	0.1	0.3	2.9	0.4	1.3	1.6
$Ru^{103-106}$	13.5	77	130	5.0	28	34
Co^{60}	[c] ND	3.1	7.2	0.2	2.1	2.3
Zr^{95}-Nb^{95}	4.7	0.3	7.2	0.5	0.4	0.7
Gross beta	22	230	150	8.9	86	44

[a] The location on Clinch River is given in terms of the distance upstream from the Tennessee River. See figure 1.
[b] The concentrations at mi. 20.8 are not measured directly but the values are calculated on the basis of levels of waste released and the dilution afforded by the river.
[c] ND—None detected.

the Clinch River. Liquid wastes originating at the ORGDP and the Y–12 Plant are discharged to Poplar Creek and thence to the Clinch River. Releases are controlled so that resulting average concentrations in the Clinch River comply with the maximum permissible levels for populations in the neighborhood of a controlled area as recommended by the National Committee on Radiation Protection (NCRP). The concentration of radioactivity leaving White Oak Creek is measured, and concentration values for the Clinch River are calculated on the basis of the dilution provided by the river.

Water samples are taken at a number of locations in the Clinch River, beginning at a point above the entry of wastes into the river and ending at Center's Ferry near Kingston, Tennessee. Stream gauging operations are carried on continuously by the U.S. Geological Survey

TABLE 5.—URANIUM CONCENTRATIONS IN THE CLINCH RIVER, OAK RIDGE AREA

[Average concentrations in pc/liter]

Sampling location	First half 1963		Second half 1963	
	No. of samples	Uranium concentration	No. of samples	Uranium concentration
Upstream from ORGDP	24	2	24	8
Downstream from ORGDP	25	2	24	2

Gamma Measurements

External gamma radiation levels are measured monthly at a number of locations in the Oak Ridge Area. Measurements are taken with a Geiger-Mueller tube at a distance of 3 feet above ground, and the results are shown in table 6 in terms of mr/hr.

TABLE 6.—EXTERNAL GAMMA RADIATION LEVELS, OAK RIDGE AREA

[Average dose rates in mr/hr]

Location	First half 1963	Second half 1963
Solway Gate	0.032	0.026
Y-12 East Portal	0.026	0.023
Newcomb Road	0.028	0.022
Gallaher Gate	0.035	0.028
White Wing Gate	0.017	0.015
Average	0.028	0.023

Previous coverage in *Radiological Health Data:*

Period	Issue
1959 and first quarter 1960	*December 1960*
Second and third quarters 1960	*March 1961*
Fourth quarter 1960	*July 1961*
First and second quarters 1961	*January 1962*
Third and fourth quarters 1961	*September 1962*
1962	*September 1963*

2. Paducah Plant, 1963

Union Carbide Nuclear Company
Paducah, Kentucky

The Paducah Plant is a Government-owned gaseous diffusion plant operated by Union Carbide Nuclear Company for the Atomic Energy Commission. The gaseous diffusion plant and the associated uranium hexafluoride manufacturing plant and uranium metal foundry process large quantities of relatively pure uranium compounds. The major sources of radiation from such materials are thorium-protactinium–234, and other beta-emitting daughters of uranium–238, concentrated in the ash produced during the fluorination process. Since the element uranium can be a physiological hazard only if it enters the body, the chemical toxicity of the uranium materials processed at the Paducah Plant overshadows any radiation danger from this element.

The environmental monitoring program consists of a continuing system for sampling air in four stations around the plant perimeter fence (not shown) and eight off-site stations; and for sampling water at one location in Big Bayou Creek, and five locations on the Ohio River as shown in figure 3.

Air

During 1963, air samples were collected continuously at each of the four air sampling stations at the plant perimeter fence and at four air sampling stations about one mile outside the fence. On July 1, 1963, four additional stations about five miles from the perimeter began operation. Samples are collected during a sampling period approximating a 168-hour week using a membrane filter. Uranium and beta activities in air for 1963 are summarized in table 7.

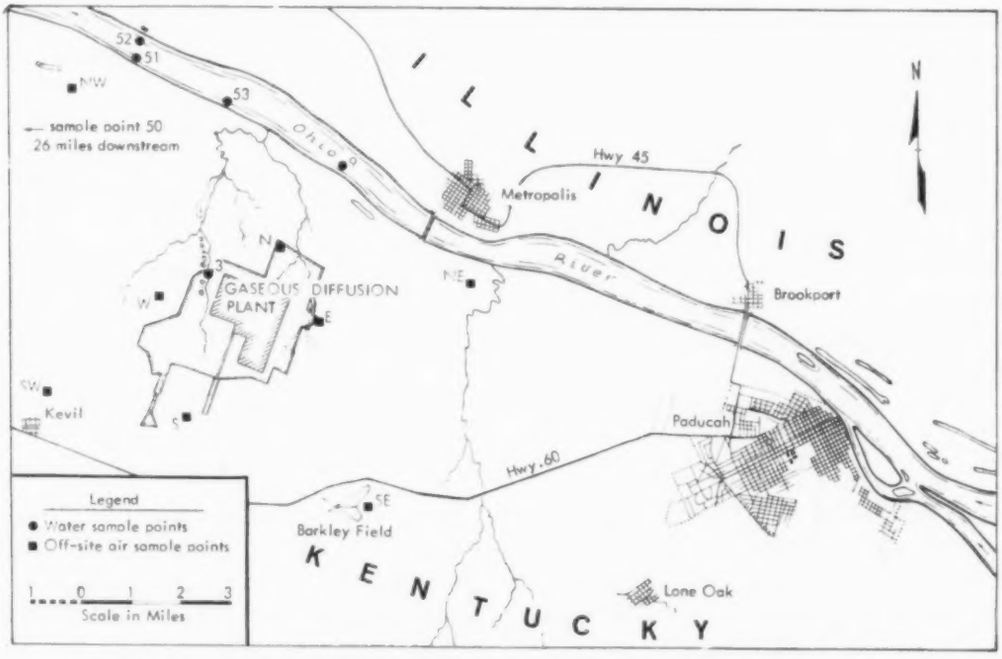

FIGURE 3.—WATER SAMPLING LOCATIONS, PADUCAH GASEOUS DIFFUSION PLANT

TABLE 7.—AIRBORNE RADIOACTIVITY IN THE PADUCAH PLANT ENVIRONMENT, 1963

[Average concentrations in pc/m³]

Sampling location	Uranium alpha			Total beta [1]		
	1st half	2nd half	Year	1st half	2nd half	Year
Plant perimeter						
N	0.06	0.050	0.05	8.2	6.4	7.2
E	0.03	0.046	0.04	7.3	4.0	5.4
S	0.03	0.029	0.03	6.8	2.7	4.5
W	0.04	0.027	0.03	6.8	2.7	4.5
One mile outside perimeter						
N	0.02	0.029	0.03	7.3	2.7	4.5
E	0.03	0.027	0.03	7.3	2.3	4.5
S	0.03	0.035	0.03	6.7	2.3	4.5
W	0.02	0.027	0.03	7.3	2.7	4.5
SE	—	0.037	—	—	2.3	—
Five miles outside perimeter						
SW	—	0.042	—	—	2.3	—
NW	—	0.091	—	—	2.3	—
NE	—	0.077	—	—	2.3	—
SE	—	0.053	—	—	2.3	—

[1] Interpreted as thorium-protactinium-234.

Water

Uranium and beta analyses of the weekly continuous samples from Big Bayou Creek, and monthly grab samples from upstream and downstream locations on the Ohio River are presented in table 8.

TABLE 8.—RADIOACTIVITY IN WATER, PADUCAH PLANT, 1963

[Concentrations in pc/liter]

Sampling location	Uranium			Beta [1]		
	First half	Second half	Year	First half	Second half	Year
Big Bayou Creek 3	43	54	72	600	800	700
Ohio River (upstream) 9	<1	<1	<1	100	600	300
Composite of 50, 51, 52, and 53 (downstream)	<1	<2	<1	100	700	400

[1] Interpreted as thorium-protactinium-234.

Recent coverage in *Radiological Health Data:*

Period	Issue
1959 and first quarter 1960	*December 1960*
Second and third quarters 1960	*March 1961*
Fourth quarter 1960	*July 1961*
First and second quarters 1961	*January 1962*
Third and fourth quarters 1961	*August 1962*
1962	*September 1963*

3. Portsmouth Area Gaseous Diffusion Plant, 1963

Goodyear Atomic Corporation
Portsmouth, Ohio

The separation of uranium isotopes by the gaseous diffusion process presents control problems similar to any chemical process using toxic solvents and extraction solutions. Natural uranium and thorium–234 are the most likely radionuclides to be released to the environment by the Portsmouth Area Gaseous Diffusion Plant. Since natural uranium is an alpha emitter and thorium–234 is a beta-gamma emitter, environmental monitoring is conducted for evidence of alpha and beta-gamma emitters to test the effectiveness of plant controls.

Air samples are collected monthly at 21 sites located from 1 to 6 miles from the plant as shown in figure 4. Monthly water samples are collected at 14 stations within 5 miles of the plant.

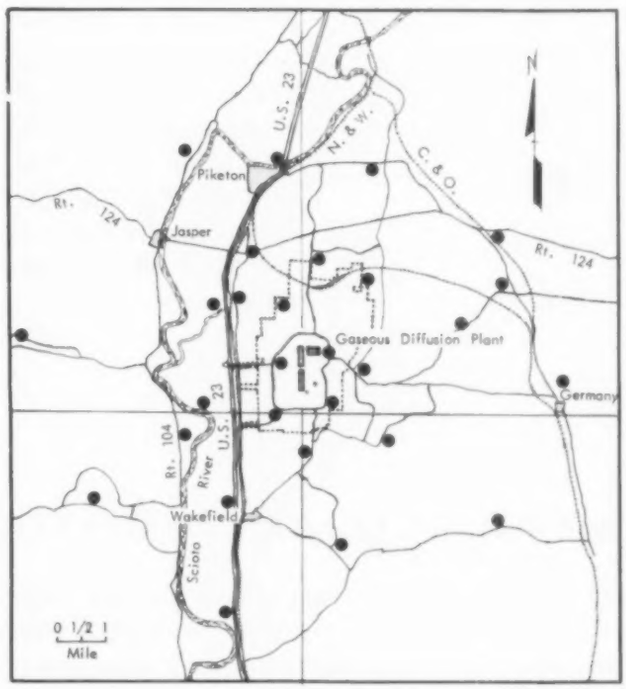

FIGURE 4.—AIR SAMPLING LOCATIONS, PORTSMOUTH GASEOUS DIFFUSION PLANT

Average alpha and beta-gamma concentrations in air and water are summarized in table 9. The external gamma levels are measured at the air sampling locations shown in figure 4 and the results included in table 9.

TABLE 9.—ENVIRONMENTAL RADIOACTIVITY, PORTSMOUTH PLANT

Measurement	Unit	January—June 1963				July—December 1963			
		No. of samples	Maximum	Minimum	Average	No. of samples	Maximum	Minimum	Average
Air (alpha concentration)	pc/m³	125	0.2	0.1	0.1	126	3.6	0.1	0.14
Air (beta-gamma concentration)	pc/m³	125	57.8	0.9	10.7	126	21.4	0.1	4.8
Water (alpha concentration)	pc/liter	79	675	0.5	27.2	70	285	0.5	20.9
Water (beta-gamma concentration)	pc/liter	79	986	14	38.9	70	720	14	37.1
External beta-gamma [a]	mrad/hr	125	0.122	0.014	0.054	126	0.127	0.012	0.056

[a] Measurements were made with open shield Geiger-Mueller tube one foot above ground. The three-foot rate (not shown) was experimentally determined to average two-thirds of the one-foot rate.

Previous coverage in *Radiological Health Data:*

Period	Issue
1959 and first quarter 1960	*November 1960*
Second and third quarters 1960	*March 1961*
Fourth quarter 1960	*August 1961*
First and second quarters 1961	*February 1962*
Third and fourth quarters 1961	*September 1962*
1962	*May 1963*

Correction for October 1962 Issue

The Atomic Energy Commission has recently advised *Radiological Health Data* of an error which appears in the October 1962 issue, page 422, table 12 entitled, "Air Monitoring Following the May 19, 1962 Event, NTS." Opposite Currant, the value for iodine–131 should read 5.6 pc/m³ rather than 516 pc/m³ as previously reported.

REPORTED NUCLEAR DETONATIONS, JUNE 1964

Three low-yield underground nuclear tests at the Nevada Test Site during June 1964 were announced by the Atomic Energy Commission. These tests, conducted on June 11th, 25th and 30th were assigned arbitrary *Radiological Health Data* reference numbers 158, 159, and 160, respectively. Tests 158 and 160 were part of the Plowshare Program to develop peaceful uses for nuclear explosives, being specifically related to excavation applications.

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UNITS AND EQUIVALENTS

Symbol	Unit	Equivalent
Bev	billion electron volt	
cpm	count per minute	
dpm	disintegration per minute	
g	gram	
kg	kilogram	1 kg = 1000 gm = 2.2 pounds
km^2	square kilometer	
kvp	kilovolt peak	
m^3	cubic meter	1 m^3 = 1000 liters
ma	milliampere	
mas	milliampere-second	
Mev	million electron volts	
mi^2	square mile	
ml	milliliter	
mm	millimeter	
mrad	millirad	
mrem	millirem	
mr/hr	milliroentgen per hour	
mμc	millimicrocurie	1 mμc = 1 nc
nc	nanocurie	1 nc = 1000 pc = 1 mμc =10^{-9} curies
nc/m^2	nanocurie per square meter	1 nc/m^3 = 1 $m\mu c/m^2$ = 1,000 $\mu\mu c/m^2$ = 1 mc/km^2 = 2.59 mc/mi^2
pc	picocurie	1 pc = 1 μμc = 10^{-12} curies
r	roentgen	
μμc	micromicrocurie	1 μμc = 2.22 dpm

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Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	ter' a
10^{9}	giga	G	ji' ga
10^{6}	mega	M	meg' a
10^{3}	kilo	k	kil' o
10^{2}	hecto	h	hek' to
10	deka	da	dek' a
10^{-1}	deci	d	des' i
10^{-2}	centi	c	sen' ti
10^{-3}	milli	m	mil' i
10^{-6}	micro	μ	mi' kro
10^{-9}	nano	n	nan' o
10^{-12}	pico	p	pe' co
10^{-15}	femto	f	fem' to

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